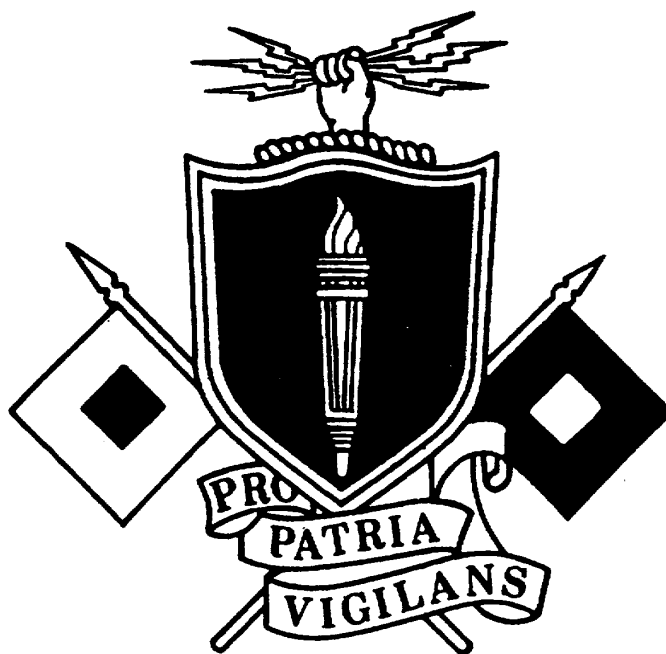


PRINCIPLES OF PHOTOGRAPHY



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT
ARMY CORRESPONDENCE COURSE PROGRAM

**A
I
P
D**

**READINESS /
PROFESSIONALISM**



**THRU
GROWTH**

U.S. ARMY STILL PHOTOGRAPHIC SPECIALIST
MOS 84B SKILL LEVELS 1 and 2 COURSE

PRINCIPLES OF PHOTOGRAPHY

SUBCOURSE NO. SS 0507

U.S. Army Signal School
Fort Gordon, Georgia

Four Credit Hours

GENERAL

The Principles of Photography subcourse, part of the Still Photographic Specialist MOS 84B Skill Level 1 and 2, is designed to teach the basic knowledge necessary for performing tasks related to the principles fundamentals of photography. Information is provided on the Basics of Photography, Application of Optics, Fundamentals of Exposure and Focusing, and Composition. This subcourse is presented in four lesson, each lesson corresponding to a terminal objective as indicated below.

Lesson 1: IDENTIFY THE BASICS OF PHOTOGRAPHY

TASK: Describe, identify, and list the theory and functions of sensitized materials, light, and optics.

CONDITIONS: Given information about the basic steps in making a photograph, the behavior of light, the color of light and their wavelengths, the types of single lenses, and the purpose of lens head.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to multiple-choice test covering the basics of photography.

This objective supports Soldier's Manual Task 113-578-1013, Photograph Subjects Using Various Focal Length Lenses; 113-578-3023, Process Black and White Film Manually; 113-578-3029, Make a Black and White Projection Print; and 113-578-3026, Process Black and White Photographic Paper.

Lesson 2: DETERMINE THE APPLICATION OF OPTICS

TASK: Describe, determine, select and state the theory and application of optics.

CONDITIONS: Given information about the focal length of a lens and its effect on perspective, image size, and the angle of view; the terms of optical center, focal plane, and infinity; and the choice of proper focal length for a given subject.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice test covering the application of optics.

This objective supports Soldier's Manual Task 113-578-1013, Photograph Subjects Using Various Focal Length Lenses; 113-578-1019, Prepare for Photographic Assignment; and 113-578-1025, Provide Guidance for Selecting Lens Focal Length.

Lesson 3: APPLY THE FUNDAMENTALS OF EXPOSURE AND FOCUSING

TASK: Calculate, determine, identify, and select the methods and the application of the fundamentals of exposure and focusing.

CONDITIONS: Given information about the light sensitivity of film, common types of mechanical shutters, shutter durations, aperture openings, daylight exposure, depth of field, hyperfocal distance and focusing.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice test covering fundamentals of exposure and focusing.

This objective supports Soldier's Manual Task 113-578-1005, Photograph Subjects with a 35mm Single Lens Reflex Camera and 113-578-1013 Photograph Subject Using Various Focal Length Lenses.

Lesson 4: BASICS OF COMPOSITION

TASK: Define and state the theory and application of composing the elements at a scene to be photographed.

CONDITIONS: Given information about the definition and principles of composition.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice test covering the basics of composition.

This objective supports Soldier's Manual Task 113-578-1015, Employ Photographic Composition, and 113-578-1023, Recommend a Photographic Format to a Requester.

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INTRODUCTION TO PRINCIPLES OF PHOTOGRAPHY

These four lessons on principles of Photography are designed to teach you the methods of performing visual information documentation within your unit. Army visual information units are becoming more tactically oriented and will require efficient and timely documentation. Much of this documentation will be performed in the field. Your ability to support the Army through Visual Information Combat Documentation, may well spell the difference between mission failure or mission accomplishment.

LESSON 1
IDENTIFY THE BASICS OF PHOTOGRAPHY

TASK

Describe, identify, and list the theory and functions of sensitized materials, light, and optics.

CONDITIONS

Given Information about the basic steps in making a photography, the behavior of light, the color of light and their wavelengths, the types of single lenses, and the purpose of a lens hood.

STANDARDS

Demonstrate competency of the task skills and knowledge by responding to the multiple-choice test covering the basics of photography.

REFERENCES

TM 11-401
TM 11-401-1

Learning Event 1:

DESCRIBE THE BASIC STEPS IN MAKING A PHOTOGRAPHY

1. Photography is the record of images produced on sensitized material by a form of radiant energy - light rays, infrared rays, and x-rays. Light is the most common form of radiant energy. A discussion of light is used in this chapter to introduce and describe the basic photographic process.

2. There are three basic steps in making a photograph: EXPOSURE, PROCESSING, and PRINTING.

a. EXPOSURE: Exposure occurs when the camera shutter is tripped, permitting reflected light from the subject to enter and thereby exposing the film. A latent (invisible) image of the subject has now been exposed onto the film's light sensitive coating, the emulsion (fig 1-1).

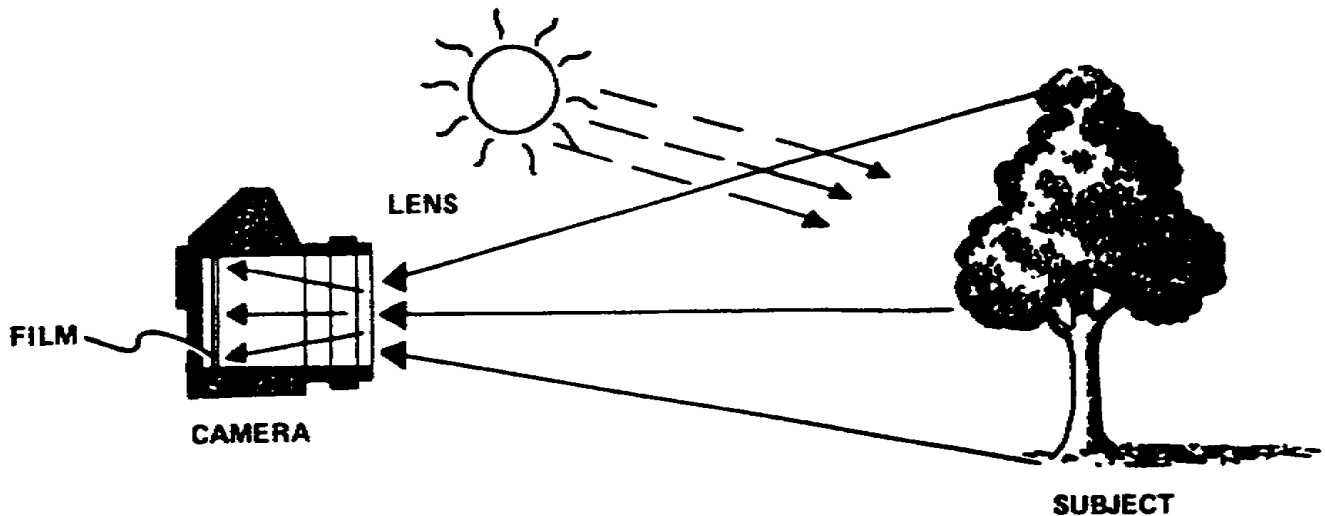


Figure 1-1. Exposure

b. **PROCESSING:** Processing, also referred to as developing consists of a series of steps that will develop the latent image into a visible image through the use of chemical solutions. These steps are:

(1) **Developer** -- Here the exposed film is immersed in a chemical solution (developer) that will change the exposed portions of the film to a visible image of the subject photographed.

(2) **Stop Bath** -- To stop the action of the developing agent and thus prevent over-developing, the film is rinsed in a diluted acetic acid solution.

(3) **Fixing** -- The film is then placed in another chemical solution which dissolves the unexposed and undeveloped parts of the emulsion. These parts are left clear.

(4) **Wash and Dry** -- Film is washed in running water so that all chemicals and unwanted particles are removed. If any chemicals remain the image will fade over time. The film is then dried, and the result is a "negative." A negative is an image of the subject photographed in which the various tones appear reversed (fig 1-2).

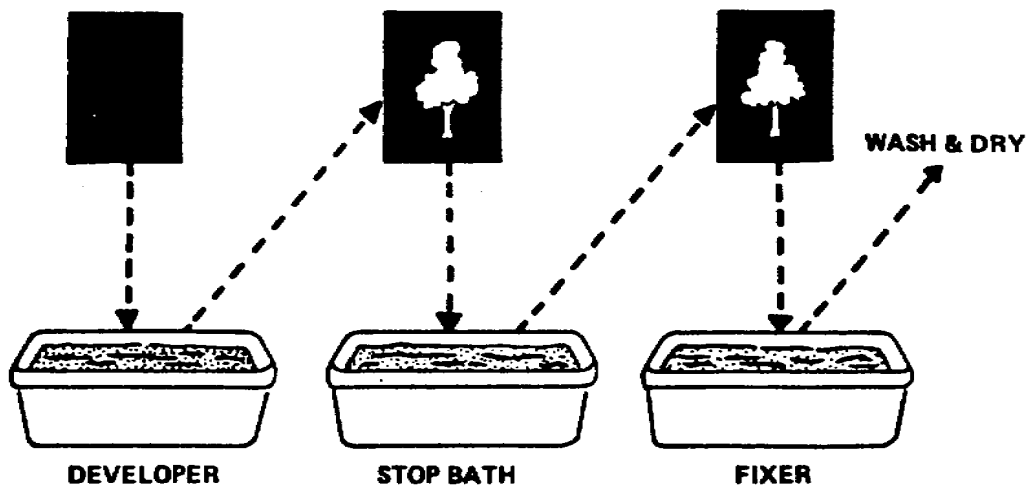


Figure 1-2. Processing steps

c. After the negative has been processed, the problem of producing a positive picture of the subject remains. This third step in the photographic process is called PRINTING. To print a photograph, light is passed through the negative to expose the emulsion on light-sensitive photographic paper. The paper reacts to the light in the same manner as the film did. Now all that needs to be done is to process the paper (fig 1-3).

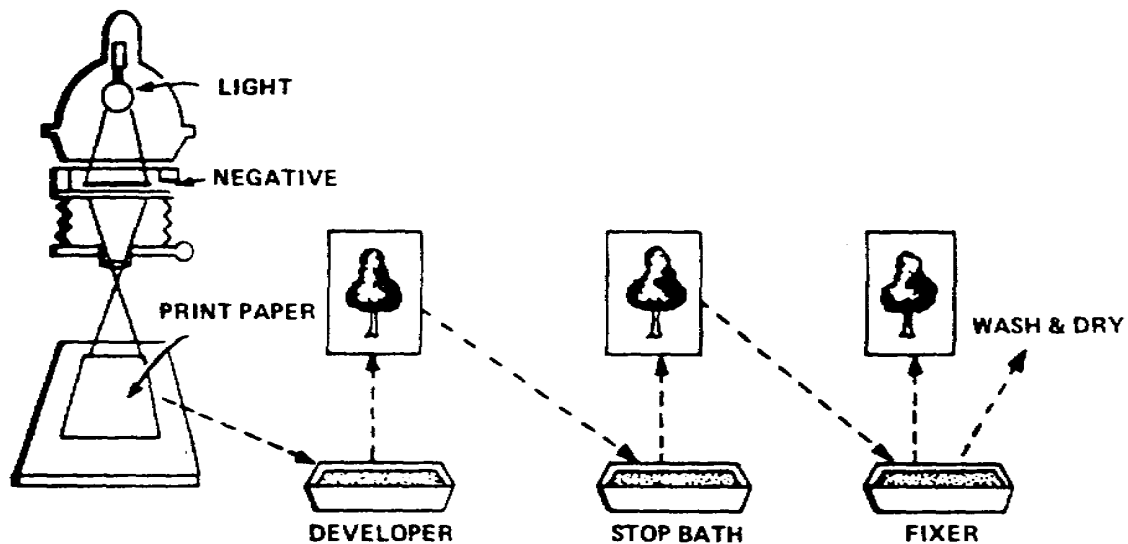


Figure 1-3. Printing

3. The photographic process described so far has been simplified. Photography is an art and a science. How well you perform these steps will determine the quality of the photograph.

DESCRIBE THE BEHAVIOR OF LIGHT

1. Light energy travels in rays. These rays differ in color depending on their wavelength but their speed remains constant as long as they travel through a medium of constant density. The speed of the light decreases in speed when it strikes a second medium of greater density and the light speed increases when it strikes a second medium of lesser density (table 1-1). When light strikes any second medium at any angle other than 90 degrees, the light rays bend (refract) (fig 1-4).

Approximate speed of light in various media in miles per second (mps)	
Air or vacuum..	186,000 mps
Water.....	140,000 mps
Ethyl alcohol..	137,000 mps
Glass.....	95,000-127,000 mps
Quartz.....	110,000 mps
Diamond.....	77,000 mps

Table 1-1. Speed of light

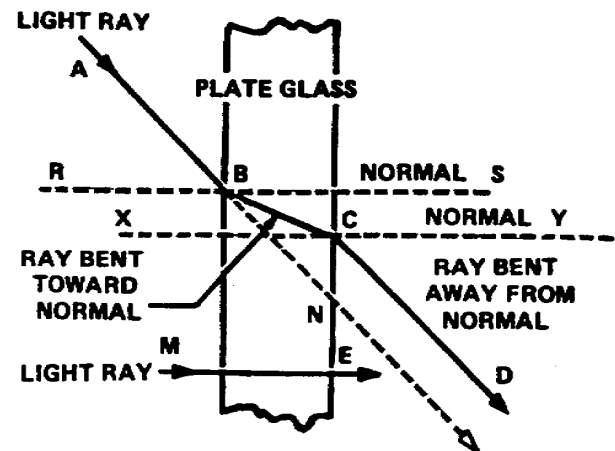


Figure 1-4. Light refraction

2. When light rays, which travel in a straight line, encounter any substance, they are either reflected, absorbed or transmitted or any combination thereof (fig 1-5).

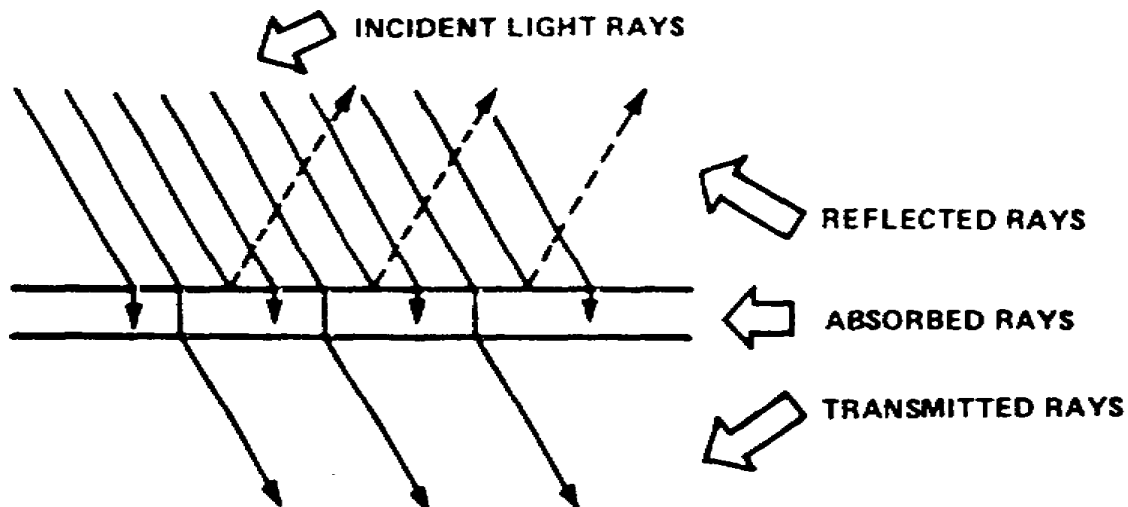


Figure 1-5. Reaction of light encountering a substance

3. The light falling upon a subject from a source is called INCIDENT LIGHT. When incident light strikes an opaque surface or object it will change direction; this change is called REFLECTION. All surfaces vary in their power to reflect light. When light strikes an object it is reflected in all directions, according to the reflecting power of the object. Dark objects reflect less light than light ones. If the surface is smooth, the reflected light is said to be SPECULAR; however, if the surface is rough, the reflected light is DIFFUSED (fig 1-6).

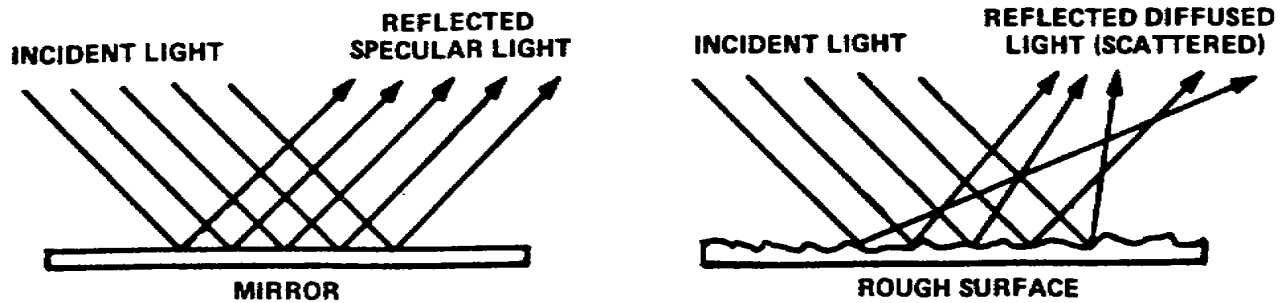


Figure 1-6. Surface effect on light

4. Reflection is an important characteristic of light. It is the reason why our eyes can see objects and how a film acquires a latent image. Rays of light that are reflected from the object and enter our eyes (or camera), are registered on the retina (or film), and converted to a visual image by the brain (fig 1-7).

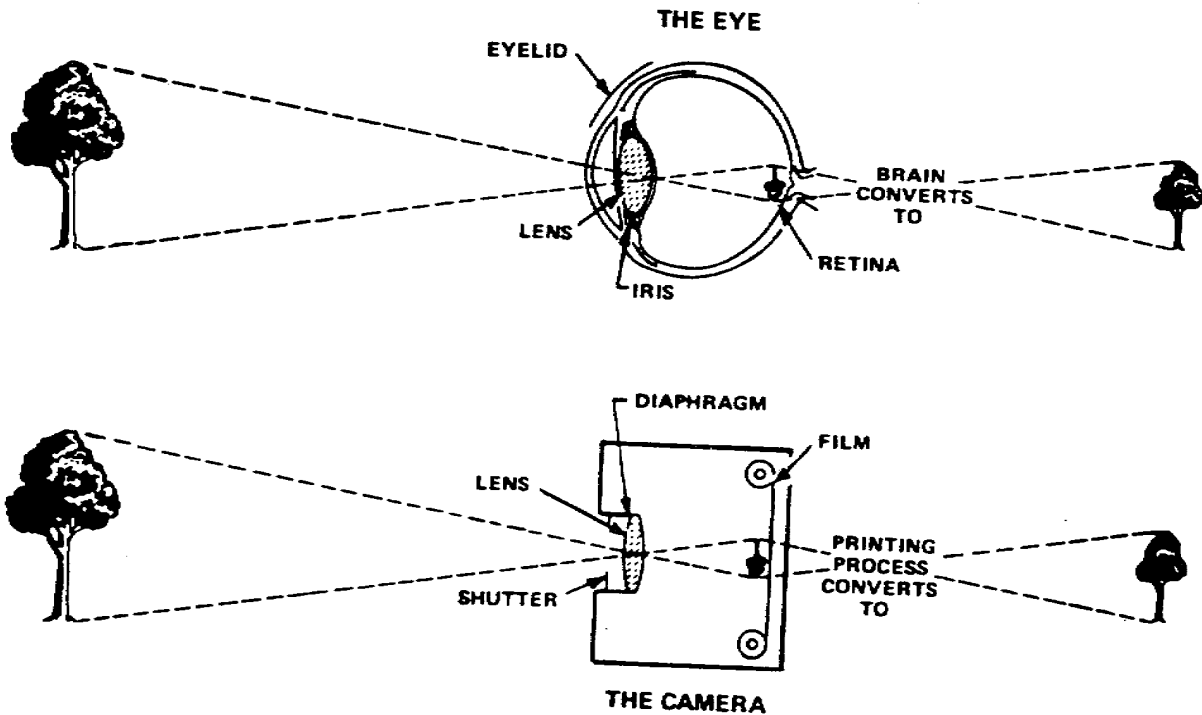


Figure 1-7. The eye of the camera

Lesson 1/Learning Event 3

Learning Event 3:

LIST THE COLORS OF LIGHT AND THEIR WAVELENGTHS

1. All forms of radiant energy are classified according to their wavelengths and frequencies. A wavelength is the distance from the crest of one wave to the crest of the next wave which is measured in nanometers (nm).* There are other units of measure such as Angstrom Units, Microns, etc. for the measurement of a wavelength. Frequency is the number of waves that pass a given point in each second (fig 1-8).

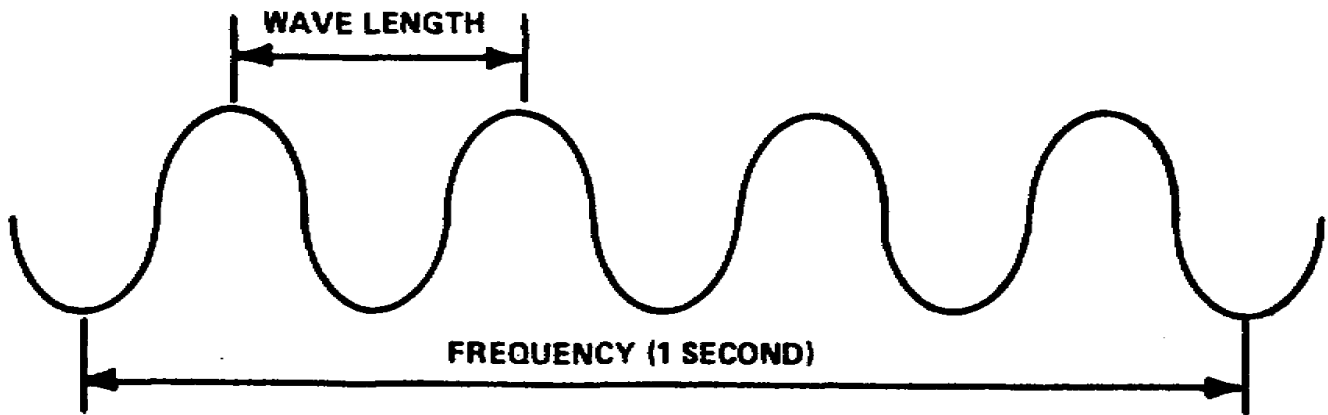


Figure 1-8. The wavelength and frequency

2. Electromagnetic Spectrum: The electromagnetic spectrum is composed of various forms of radiant energy (fig 1-9), such as gamma rays, x-rays, light rays, radio waves, etc. The visible portion of the electromagnetic spectrum consist of light rays with wavelengths from 400 to 700 nanometers. The primary colors used in photography are Blue from 400 to 500, Green from 500 to 600, and Red from 600 to 700.

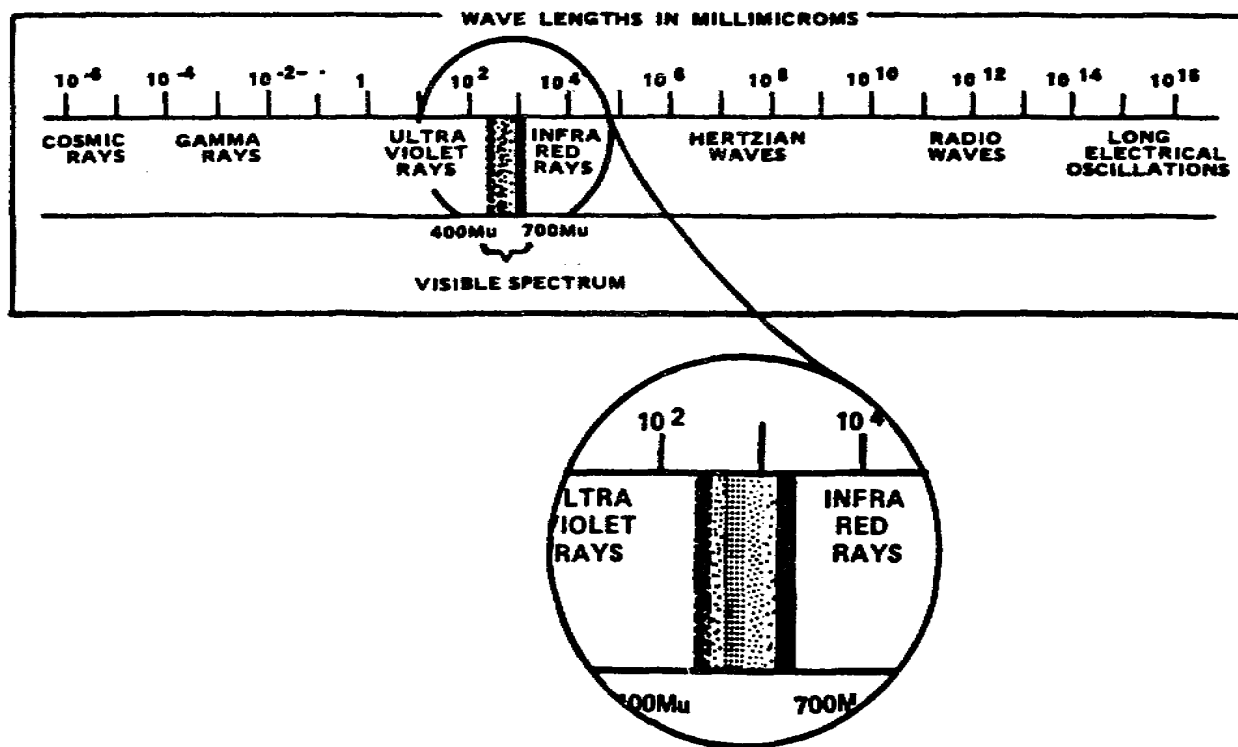


Figure 1-9. The electromagnetic spectrum

3. Composition of White Light. White light is composed of all the wavelengths of the electromagnetic spectrum. Light can be passed through a prism to determine its composition (fig 1-10). Each color of the spectrum represents light vibrating at a different frequency or wavelength. The shorter the wavelength, the more the rays are bent, or refracted, when passing through a transparent medium. Red light has the longest wavelength, and violet the shortest, thus the red light is bent the least and the violet light is bent the most.

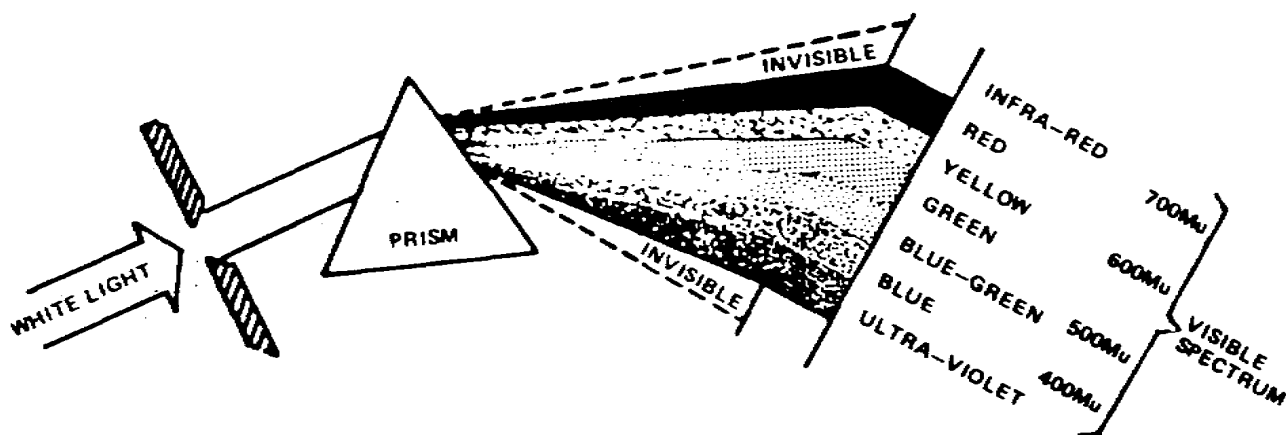


Figure 1-10. The dispersion of light

Learning Event 4:
DETERMINE THE INTENSITY OF ILLUMINATION

1. In photography, light is the most important ingredient. The intensity of illumination on an object depends upon the strength of the light source in candlepower and the distance from the light source to the object. Light intensity diminishes inversely with the square of the distance from a light source to an object.

2. In figure 1-11, a card is placed 1 foot, 2 feet, 3 feet, and 4 feet from a light source. Assume the card, which is one foot from the light source, is receiving 640 foot candles of illumination. If you double the distance to two feet, the card receives $\frac{1}{4}$ the illumination or 160 foot candles at one foot. If you move the card to 3 feet, it receives $\frac{1}{9}$ the amount of light or 71 foot candles. If you move the card to four feet, it receives $\frac{1}{16}$ as much light as it did at 1 foot.

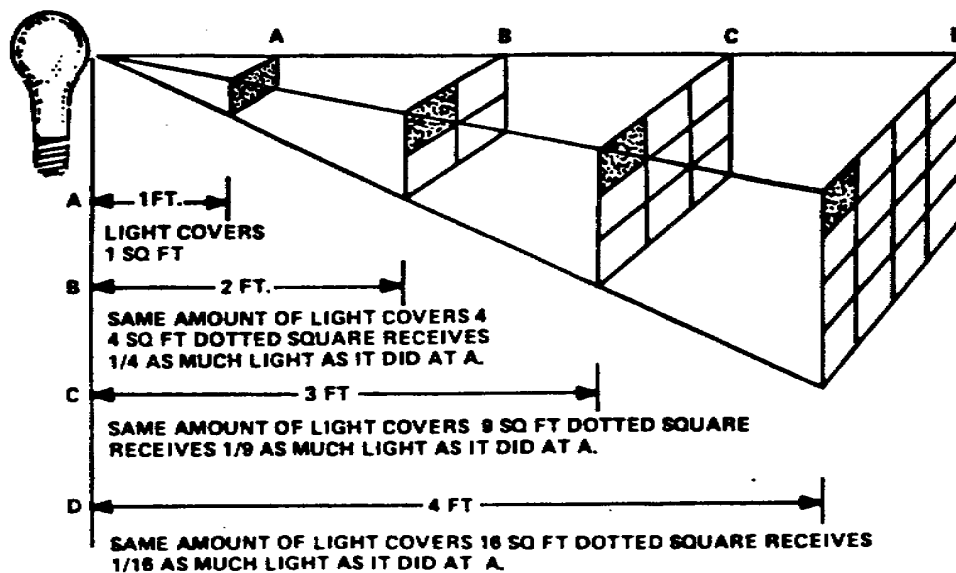


Figure 1-11. How light loss intensity

Learning Event 5:

IDENTIFY THE BASIC TYPES OF SINGLE LENSES

1. The purpose of a lens is to refract light rays to a sharp, clear image. Camera lenses are designed to function with the least amount of error and to reproduce objects in a practical object-image size relationship (fig 1-12). Pinhole lenses are not practical for general photography as the size of the pinhole must be very small to produce a nearly clear, focused image. Due to the size of the pinhole, a long exposure time is necessary to expose an image.

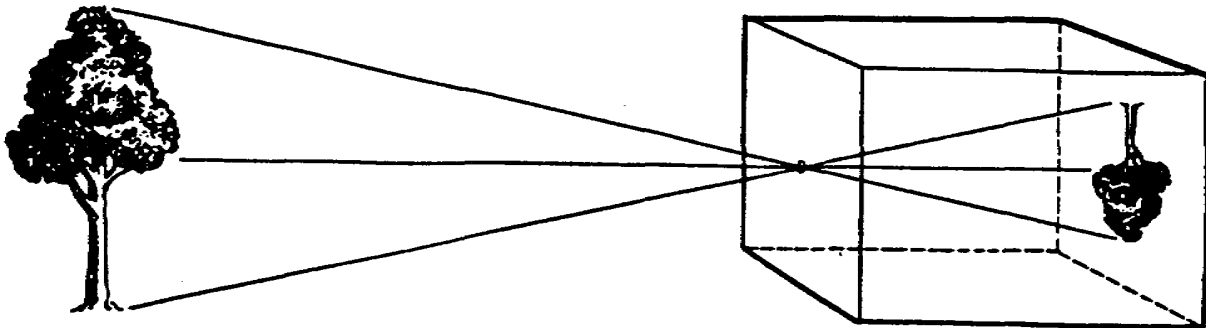


Figure 1-12. The pinhole camera

2. A camera lens is a polished spherical and symmetrical glass that refracts light rays from an image of an object to the rear wall (focal plane) of the camera. A lens transmits more light than a pinhole, producing an increase of brightness and an improvement of image sharpness (fig 1-13).

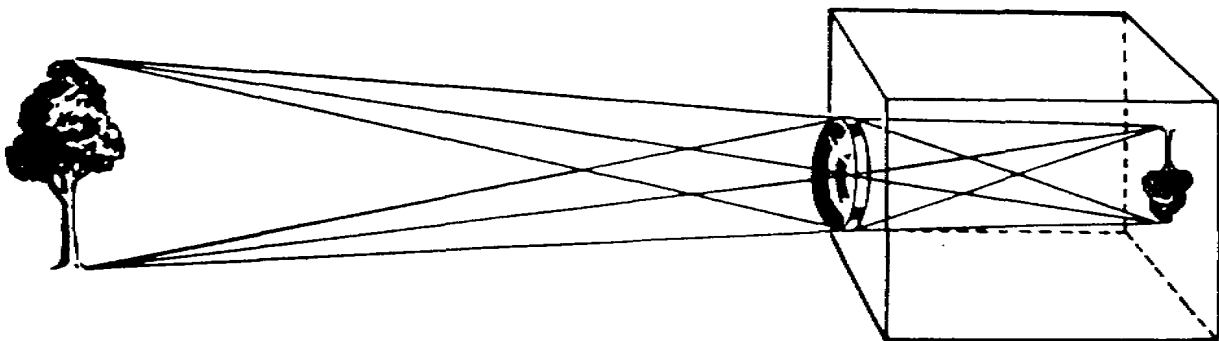


Figure 1-13. The simple camera

3. Types of Single Lenses. There are two general categories of single lenses: positive and negative.

a. Positive lenses are convex on one or both surfaces and bend light rays towards its center (fig 1-14).

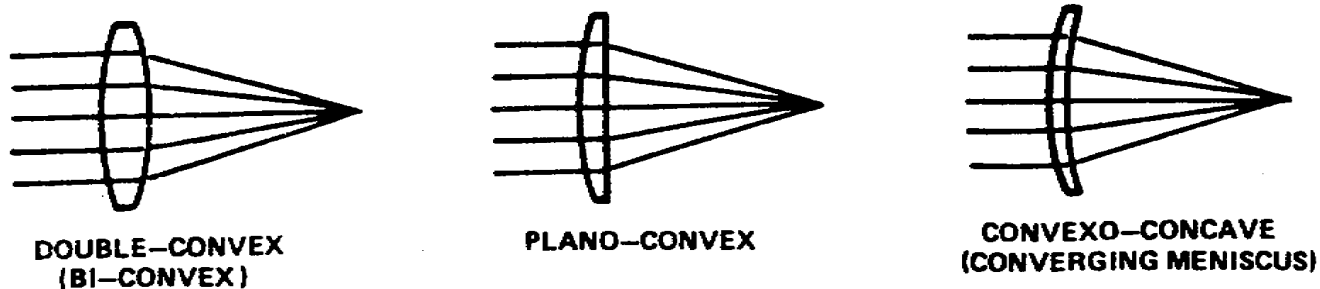


Figure 1-14. Positive lenses

b. Negative lenses are concave on one or both sides and bend light rays away from its center (fig 1-15).

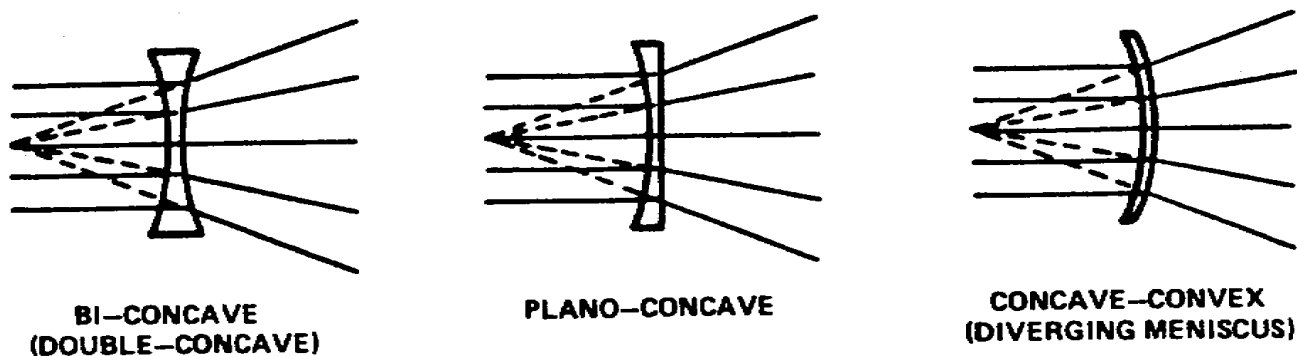


Figure 1-15. Negative lenses

4. A simple rule of thumb which can be used in determining the category of any single lens is that light rays always bend towards the thickest part of a lens.

Learning Event 6:

DESCRIBE THE CAUSE AND THE CORRECTION OF LENS

1. Optical Flare primarily caused by unwanted light rays striking the lens surface and the internal reflections from the glass-to-air surfaces of the lens elements. This will reduce the quality of image sharpness (fig 1-16).

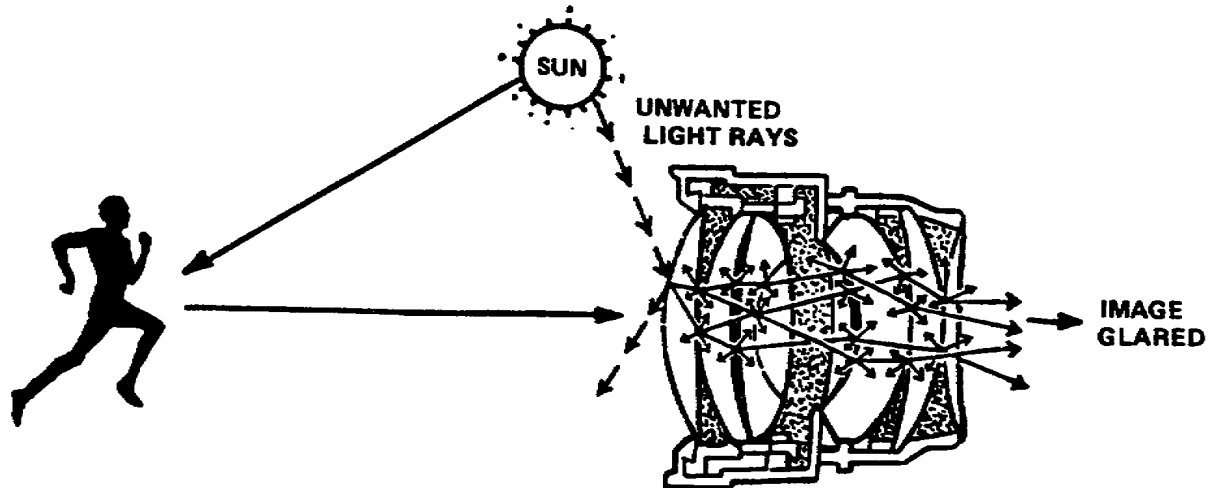


Figure 1-16. Optical flare

2. Optical Flare can be greatly reduced or eliminated by the use of a lens hood or a lens shade. A lens hood or lens shade is a tubular attachment that is mounted on the lens. It shades the surface of the lens by blocking unwanted light rays as shown in Figure 1-17. It is good practice to have a lens hood or lens shade mounted to your lens at all times.

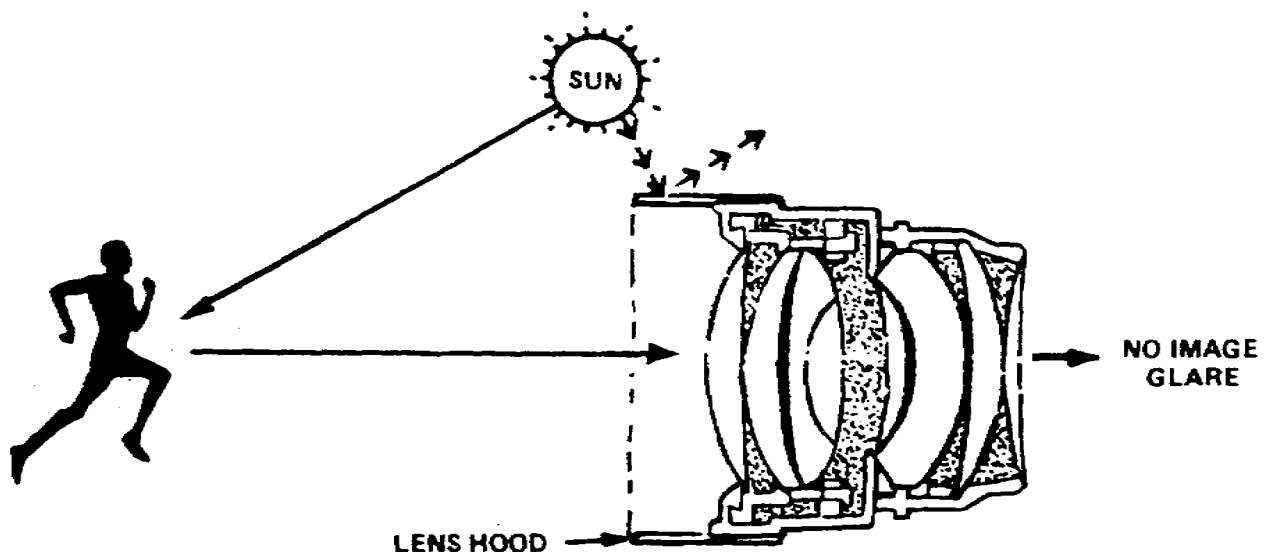


Figure 1-17. Optical flare eliminated

PRACTICE EXERCISE

1. What are the three steps in the photographic process? _____

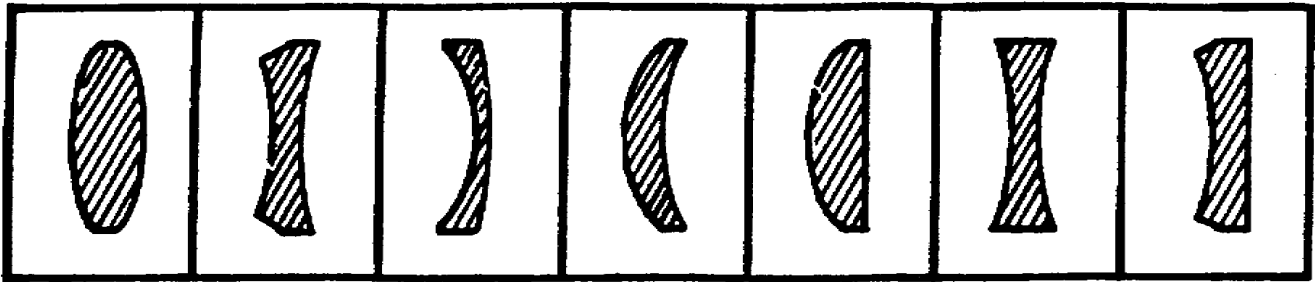
2. List the processing steps. _____

3. What step in the photographic process is employed to make a positive picture of the subject? _____

4. What is the emulsion of film and paper sensitive to? _____

5. When light rays encounter a substance, they will either be _____,
_____, and/or _____.
6. The banding of transmitted light through a transparent medium is referred to as _____.
7. Light rays from its source are referred to as _____.
8. When light rays strike a surface of an object and change direction, the light rays are said to be _____.
9. Dark objects will absorb more light and _____ less light than lighter objects.
10. Fill in the color of light that equals the wavelengths in the electromagnetic spectrum:
 - a. Wavelengths from 400 to 500 nanometers = _____ light.
 - b. Wavelengths from 500 to 600 nanometers = _____ light.
 - c. Wavelengths from 600 to 700 nanometers = _____ light.
 - d. Wavelengths from 400 to 700 nanometers = _____ light.
11. When an object is moved "two times" closer to its light source, how much more or less light intensity would the object receive? _____

12. Determine the two general categories of the single lenses below by labeling beneath each lens with the letter "P" for positive lens or the letter "N" for negative lens. Note: The light direction is from left to right.



13. Light rays will always bend (refract) towards what part of the lens?

14. Optical flame can be reduce or eliminated by use of a _____.

ANSWERS TO PRACTICE EXERCISES

1. Exposure, processing, and printing, Lesson 1/Learning Event 1
Para 2.
2. Developing, stop bath and fixing, Lesson 1/Learning Event 1
Para 2b.
3. Printing, Lesson 1/Learning Event 1
Para 2c.
4. Light, Lesson 1/Learning Event 1
Para 2a.
5. Transmitted, reflected, and/or absorb, Lesson 1/Learning Event 2
Para 2.
6. Refraction, Lesson 1/Learning Event 2
Para 1.
7. Incident light, Lesson 1/Learning Event 2
Para 3.
8. Reflected, Lesson 1/Learning Event 2
Para 3.
9. Reflect, Lesson 1/Learning Event 2
Para 4.
10. a. Blue
b. Green
c. Red
d. White
Lesson 1/Learning Event 3
Para 2.
11. Four times more light, Lesson 1/Learning Event 4
Para 2.
12. a. P
b. N
c. N
d. P
e. P
f. N
g. N
Lesson 1/Learning Event 5
Para 3a and b.

13. The thickest part, Lesson 1/Learning Event 5
Para 4.
14. Lens hood, Lesson 1/Learning Event 6
Para 2.

LESSON 2
DETERMINE THE APPLICATION OF OPTICS

TASK

Describe, determine, select, and state the theory and application of optics.

CONDITIONS

Given information about the focal length of a lens and its effect on perspective, image size, and the angle of view; the terms of optical center, focal plane, and infinity; and the choice of proper focal length for a given subject.

STANDARDS

Demonstrate competency of the task skills and knowledge by responding to the multiple-choice test covering the application of optics.

REFERENCES

TM 11-401
TM 11-401-1
TM 11-401-2

Learning Event 1:

DESCRIBE THE OPTICAL TERMS OF FOCAL LENGTH, FOCAL PLANE, OPTICAL CENTER, AND INFINITY.

1. In photography, we speak of lens focal length as the distance between the optical center of lens to the focal plane (film plane) of the camera when the lens is focused on infinity. To understand this definition it is essential that you fully understand the terms local plane, optical center, and infinity.

a. FOCAL PLANE: The surface (plane) on which an image transmitted by a lens is brought to sharp focus; the surface or area at the back of the camera occupied by the film (fig 2-1).

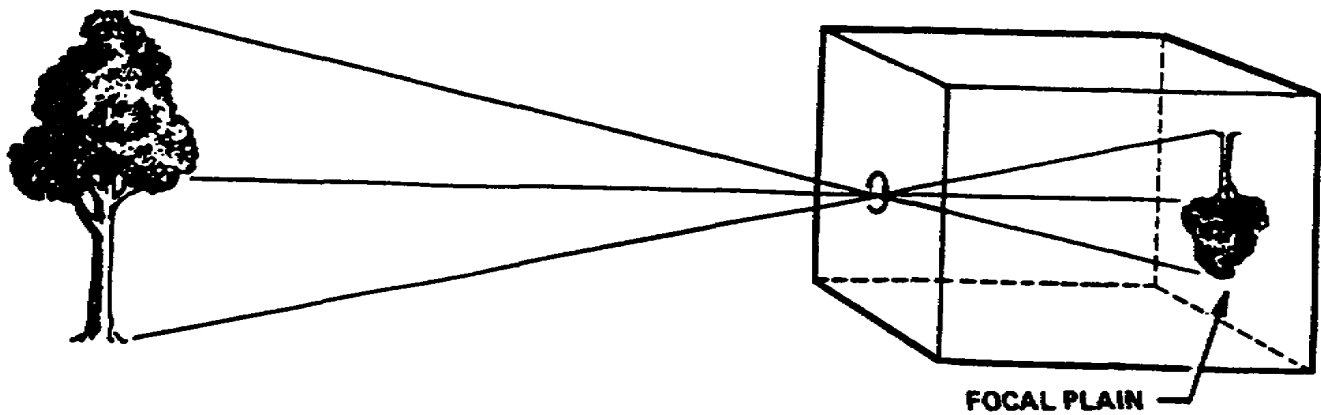


Figure 2-1. Focal plane

b. Optical Center. The optical center of a lens is a point, usually (although not always) within a lens, at which the rays of light from two different sources entering the lens are assumed to cross (fig 2-2).

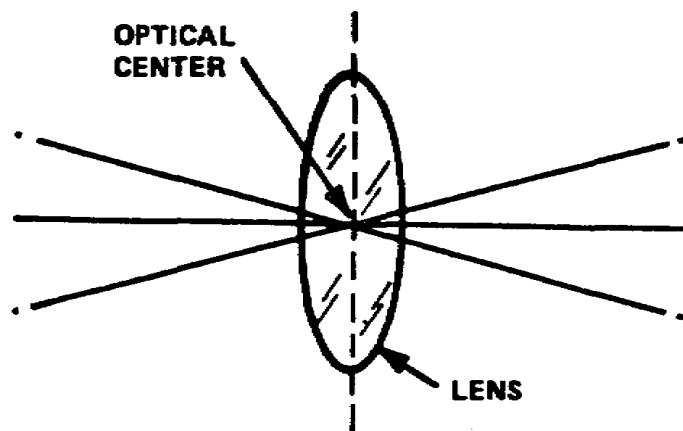


Figure 2-2. Lens

c. Infinity. Infinity is a distance so far removed from the camera lens that the rays of light reflected to the lens from a point at that distance may be regarded as parallel. Infinity is expressed by the symbol " ∞ " and is a setting on a lens focusing scale.

2. Photographic lenses are measured according to their focal length which is normally imprinted somewhere on the lens mounting, usually on the front surface of the lens barrel (fig 2-3).

- a. This focal length information is given in inches or in millimeters.
- b. Focal length is frequently employed to indicate the size of a lens.

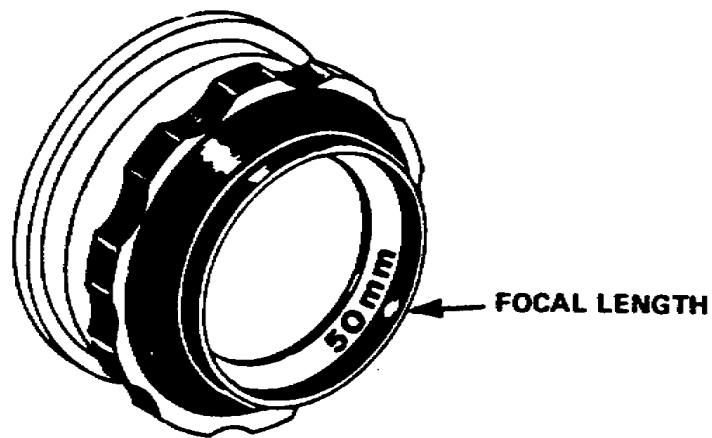


Figure 2-3. Location of focal length

c. Therefore, a lens labeled as an 8-inch or 200-mm lens indicates that when it is focused on a point at infinity, the distance from its optical center to the focal plane will be eight inches.

NOTE: The remaining lesson on focal lengths in this subcourse will be based on lenses used for 35mm camera format, since most military photographers possess this camera equipment.

Learning Event 2:

DETERMINE THE EFFECT ON IMAGE SIZE FOR A GIVEN LENS

1. The focal length of a lens determines the image size on the focal plane. For example, three different focal length lenses are focused at the same distance. This will produce different image sizes on the focal plane. If the 50mm, normal lens, produces a 10mm image size, then the 25mm, wide angle, will produce an image size of 5mm, and the 100mm, telephoto, will produce an image size of 20mm (fig 2-4).

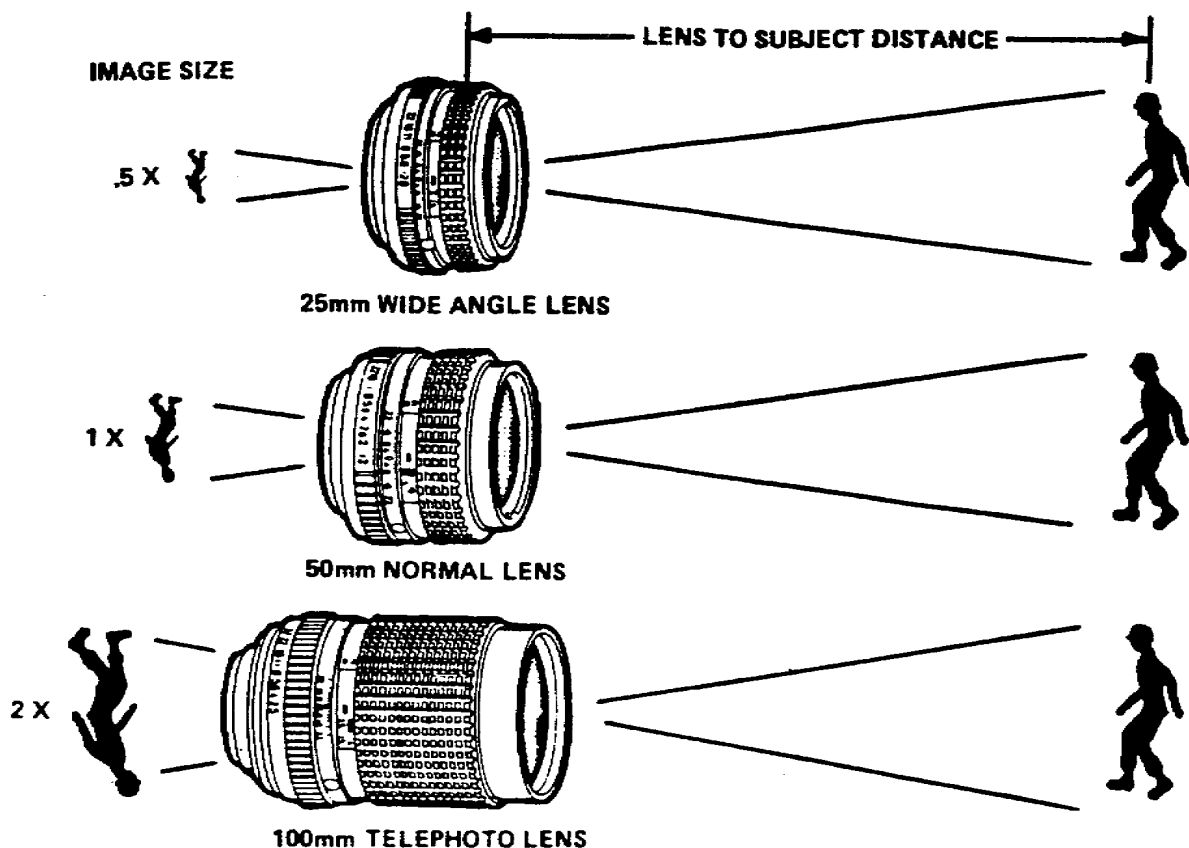


Figure 2-4. Different image sizes

2. With the lens to subject distance the same, the longer the focal length the larger the image size on the focal plane. A shorter focal length will produce a smaller image size on the focal plane.

3. By changing focal length and subject distance you can maintain the same image size. For example, assuming that you are using a normal 50mm lens, the same image size is obtained by doubling the focal length to 100mm as the lens to subject distance is doubled (fig 2-5).

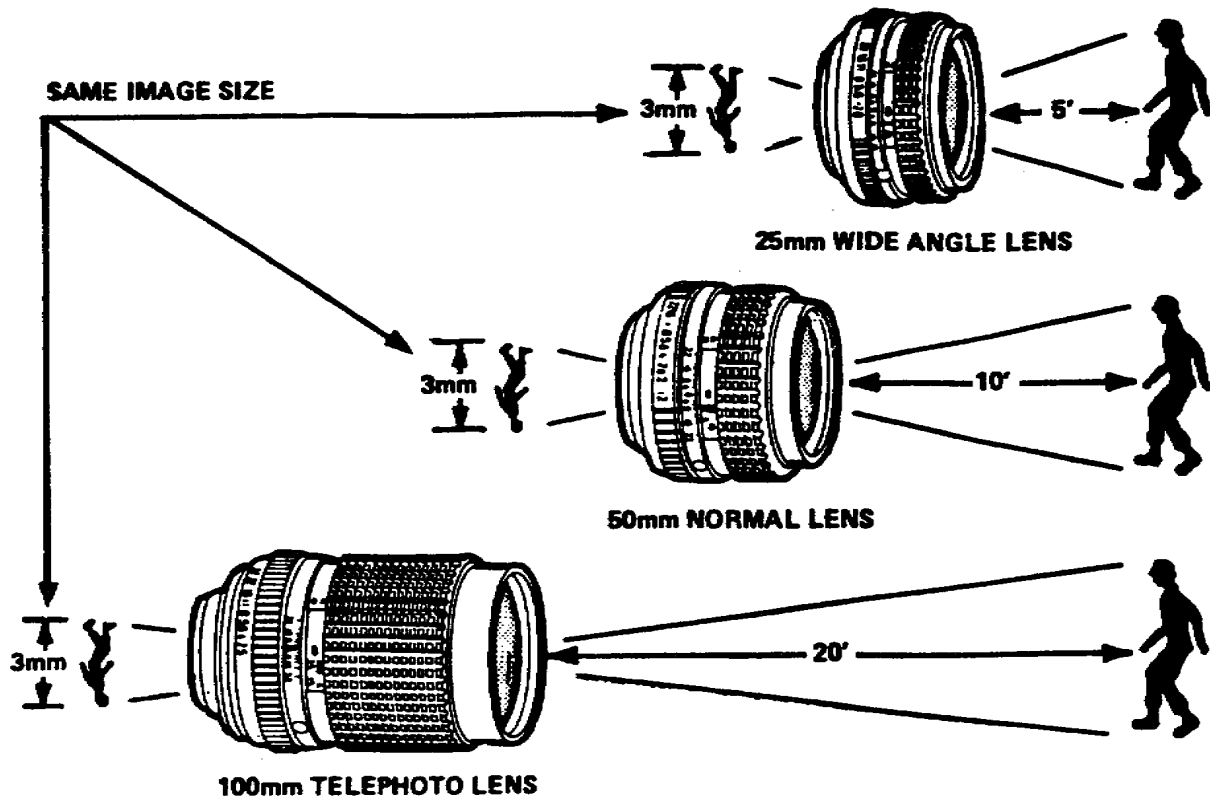


Figure 2-5. Different lens to subject distance

4. There are times when you want to maintain the same image size but you must move closer or farther away from your subject. This is done by using a long focal length if you must move away from your subject or a wide angle lens when you must move close to the subject.

5. Maintaining the same image size on the focal plans from three different subject sizes can be obtained from three different focal length lenses at the same lens to subject distance. For example, in figure 2-6 an image size of 5mm on the focal plane is produced with each lens by doubling the focal length as the subject is reduced in half while maintaining the same lens to subject distance. The figure illustrates an example of:

a. A 25mm lens will produce a 5mm image of a 60 foot tall building at a given lens to subject distance.

b. A 50mm lens will also produce a 5mm image size of a 30 foot tall building at the same given lens to subject distance.

c. And the 100mm lens will produce a 5mm image size of a 15 foot tall building at the same given lens to subject distance.

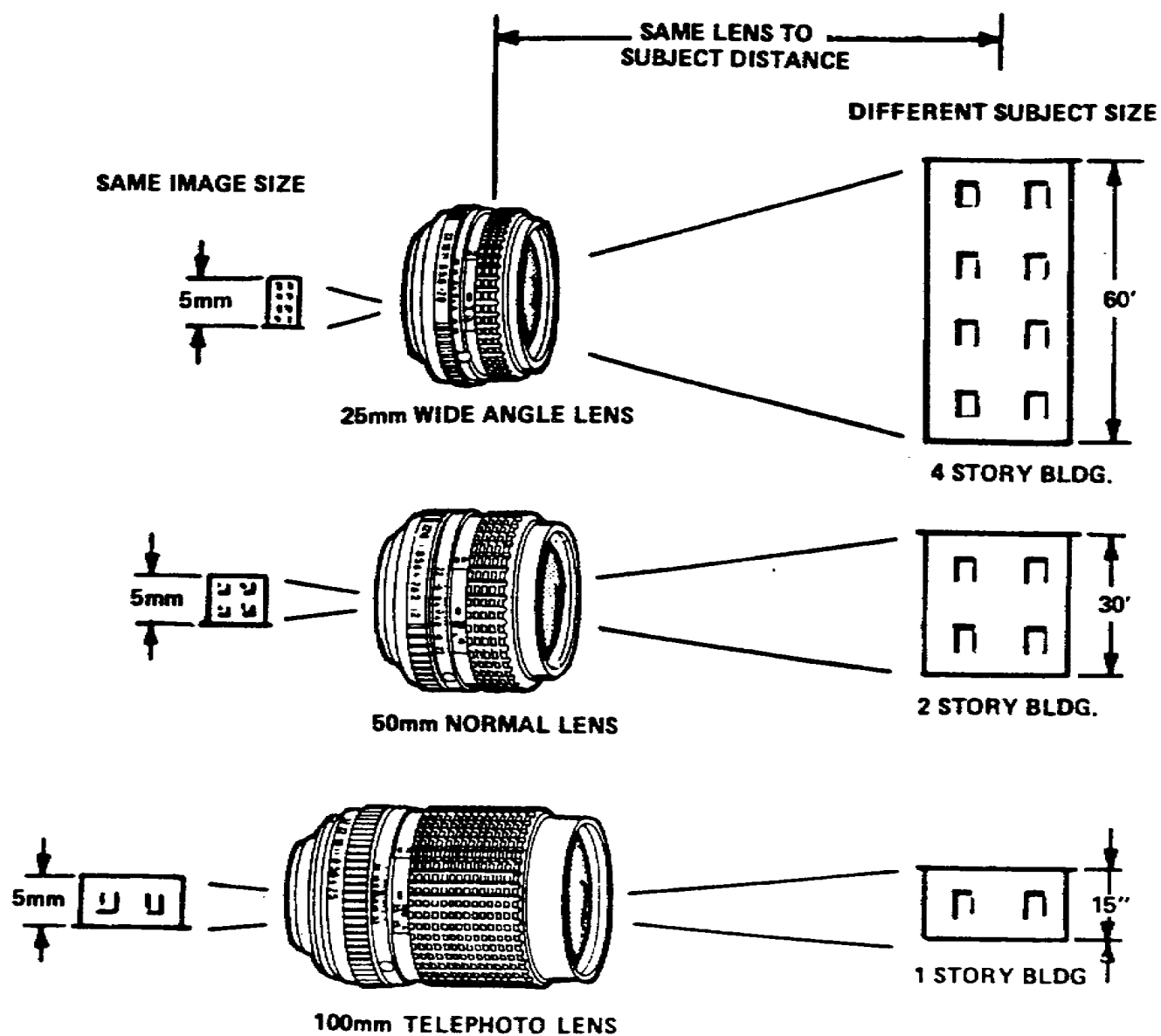


Figure 2-6. Different subject sizes

Learning Event 3:

DETERMINE THE ANGLE OF VIEW FOR A GIVEN FOCAL LENGTH LENS

1. The focal length of a lens determines its angle of view. As the focal length increases, the angle of view decreases (fig 2-7).

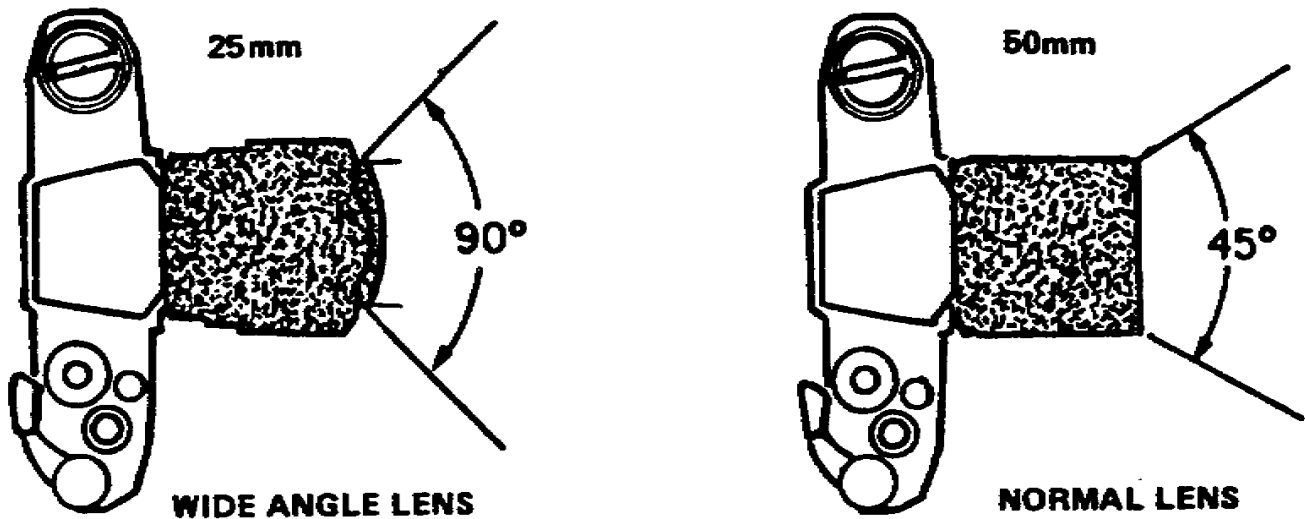


Figure 2-7. The angle of the 50mm lens is one-half that of the 25mm lens

2. The wider the angle of view, the more subject area is covered (fig 2-8).

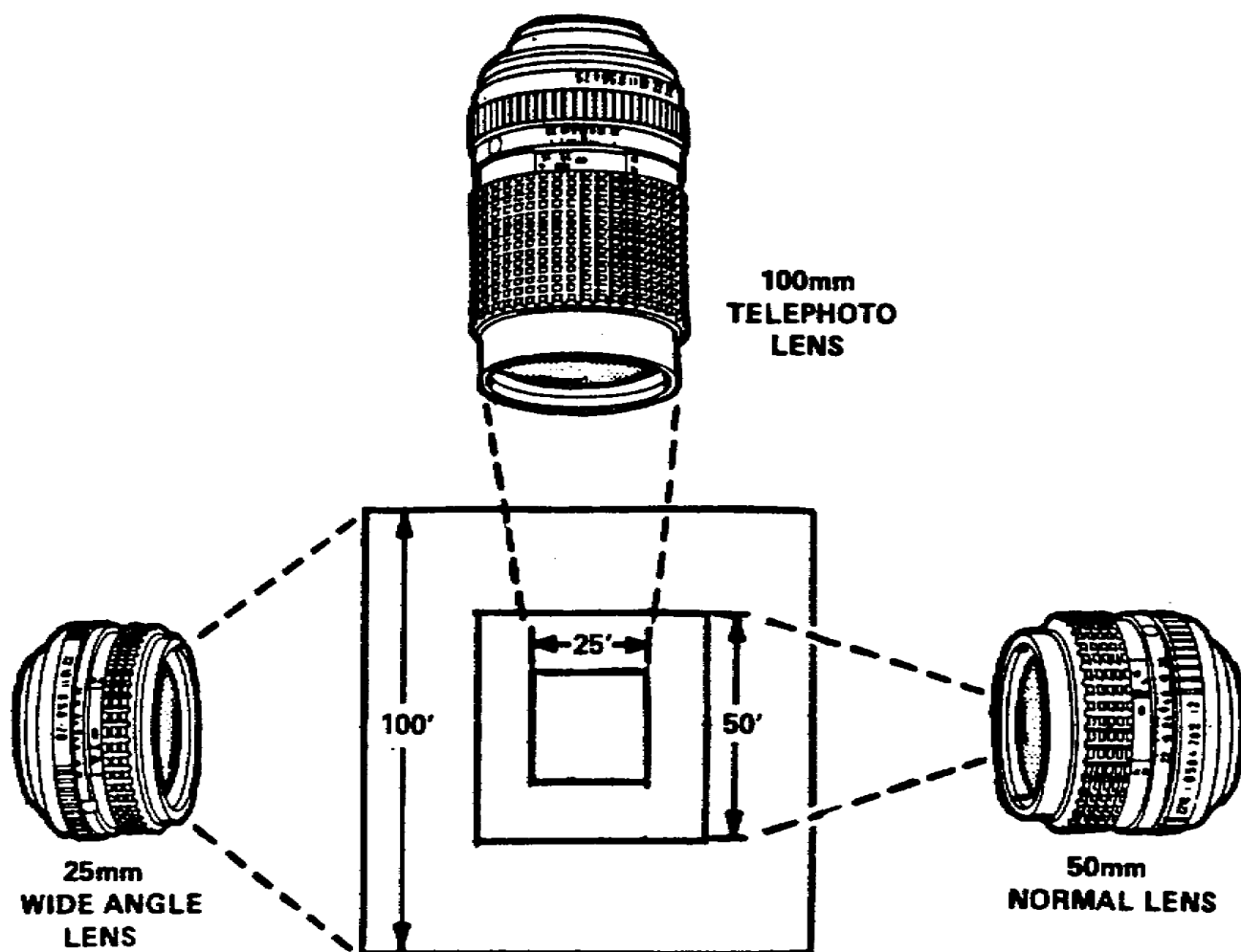


Figure 2-8. Angle of view and subject coverage

3. Photographic lenses are classified as normal, wide angle and telephoto lenses according to their angle of view (fig 2-9).

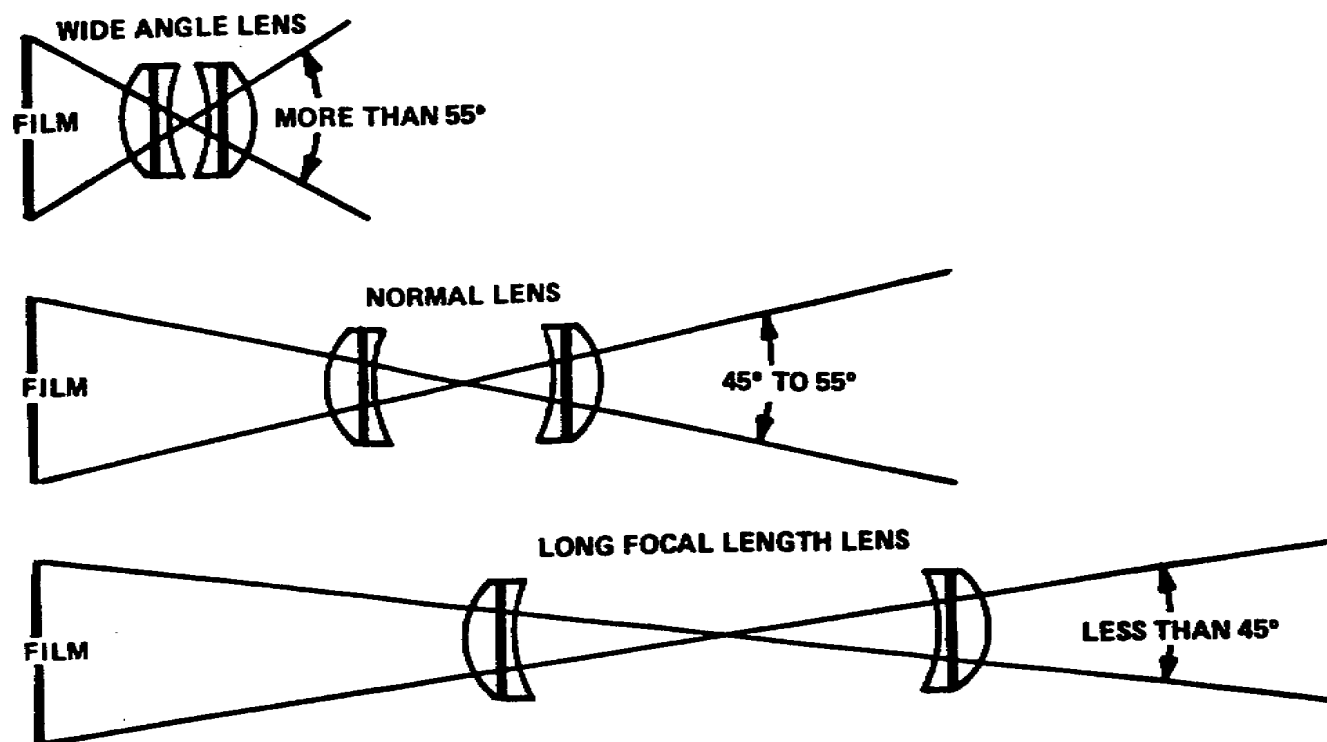


Figure 2-9. Angle of view for various focal length lenses

4. Wide angle lenses have an angle of view of more than 55 degrees. Normal lenses have an angle of view of 45 to 55 degrees. Telephoto lenses have an angle of view less than 45 degrees.

Learning Event 4:

STATE THE EFFECT ON PERSPECTIVE FOR A GIVEN FOCAL LENGTH LENS

1. The human eye sees objects in three dimensions: height, width and depth. A photographic lens reproduces objects onto the focal plane in only two dimensions: height and width. The missing dimension, depth, is suggested by the relative size and position of the various objects in a picture. Note in figure 2-10 that you are looking down a road with evenly spaced trees on both sides. Notice how the road decreases in width and the trees appear closer to each other as the depth increases.



Figure 2-10. Depth as viewed by the eye or normal lens

2. Changing the focal length of a lens DOES NOT change the actual depth perspective. Depth perspective is dependent on lens-to-subject distance. Focal length, however, changes the apparent perspective because the camera does not record as much of a scene with a telephoto lens as it does with a normal lens (fig 2-11).

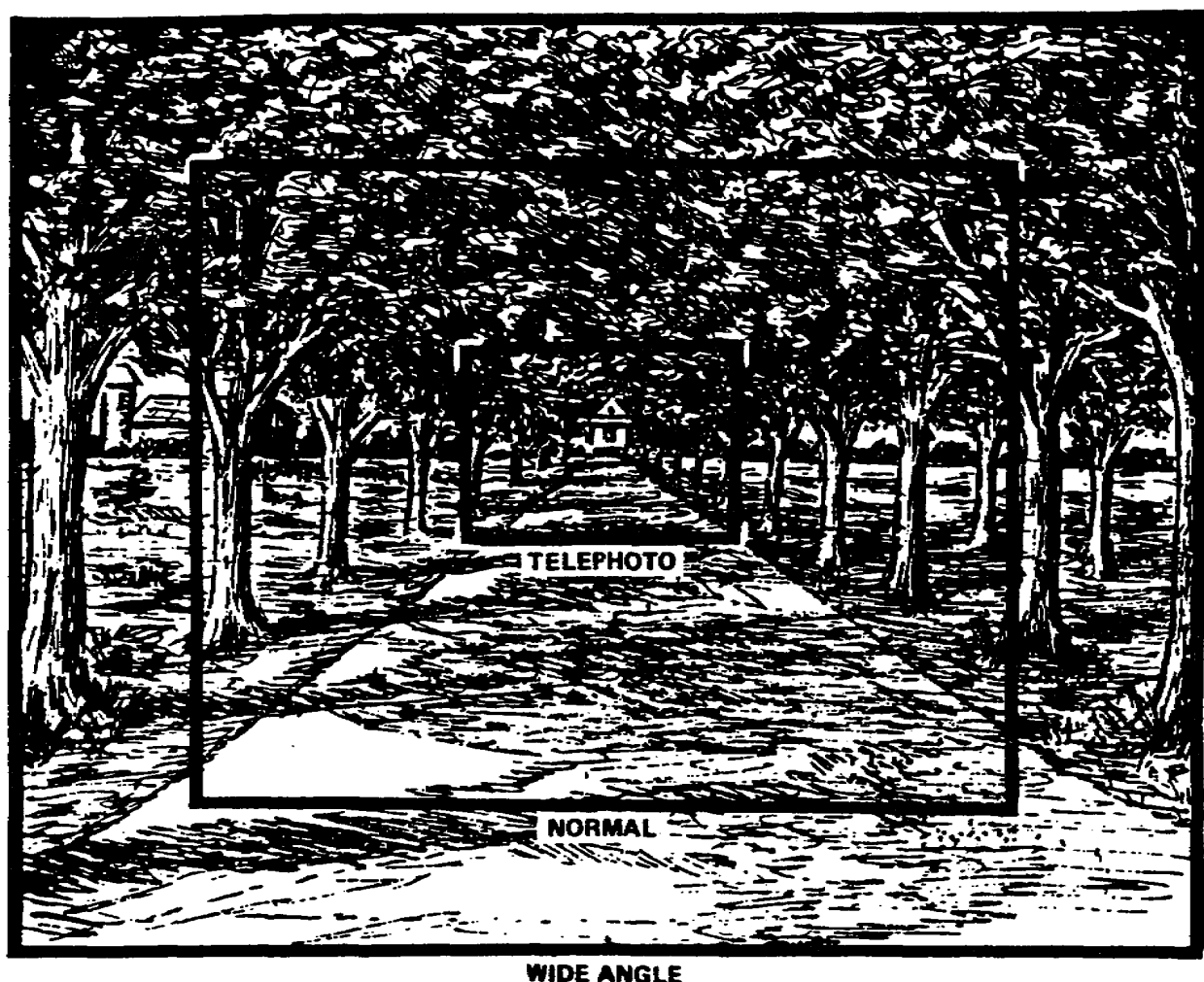


Figure 2-11. The apparent depth perspective of three different focal length lenses

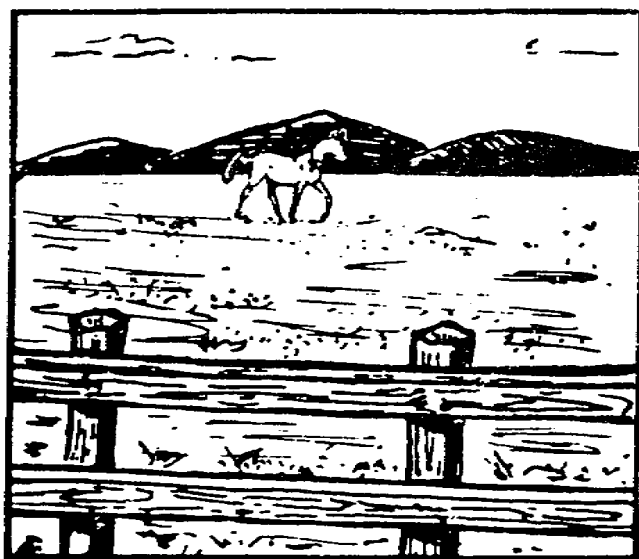
3. A telephoto lens, as you recall, increases image size and reduces the angle of view. Thus objects in the background appear closer to objects in the foreground. This apparent foreshortened perspective of depth is the compression of the space between the foreground and background.

4. A wide angle lens has an opposite effect on depth perspective. Objects in the background appear further away than normal because of increased angle of view and decreased image size.

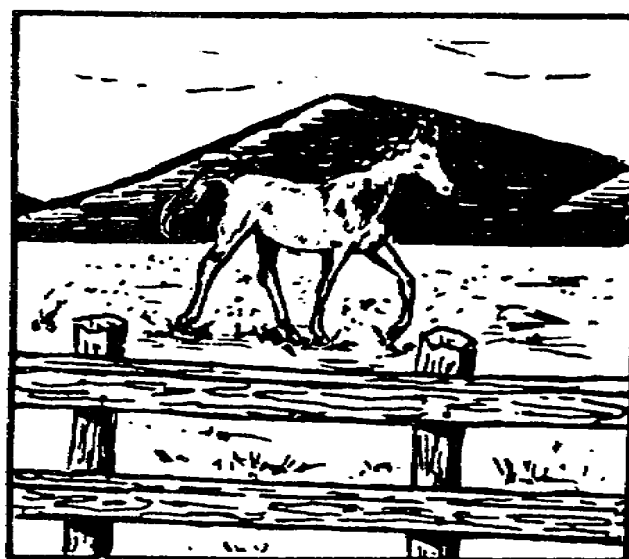
5. Remember that the perspective of depth is NOT dependent on the lens focal length. It is dependent on the lens-to-subject distance. A choice of lenses of different focal lengths, however, does enable you to get the desired image size at the selected distance for best depth perspective. For example, suppose you come across a scene (fig 2-12). A wooded rail fence is in the foreground and a horse in the field. The horse is 100 feet behind the fence; you are 10

feet from the fence. The fence is essential to your photograph and you use a 50mm lens. The result is that the horse is 110 feet from the camera and is too small in relation to the fence.

6. Now change your distance from the fence from 10 feet to 40 feet and use a 200mm lens. The fence at this distance with a 200mm lens is the same size as it was at 10 feet with a 50mm lens. The horse is now 140 feet from the camera. The image size of the horse is four times larger. In the photograph, it appears as if the horse is 35 feet away or 25 feet behind the fence. The result is an interesting photograph with a pleasing composition. Choosing a viewpoint and then selecting a focal length for image size is one of the most important functions to consider when selecting a lens focal length.



50 MM LENS 10 FT FROM FENCE



200 MM LENS 40 FT FROM FENCE

HORSE IS AT 100 FT FROM FENCE IN BOTH PHOTOGRAPHS

Figure 2-12. Foreshorten Perspective/compression of space

PRACTICE EXERCISE

1. The point where light rays cross in a lens assembly is referred to as the _____ of a lens.
2. The _____ is where the image is brought to a sharp focus at the back of the camera occupied by the film.
3. The distance from the camera lens where the light rays become parallel is referred to as _____.
4. The symbol " " on a camera lens indicates that the lens is focused on what?

5. _____ is the distance from the optical center of a lens to the focal plane when the lens is focused on infinity.
6. The image size on the focal plane is determined by the size of the subject, the lens to subject distance and the _____ of the lens.
7. What new focal length lens would you select to double the image size while maintaining the same lens to subject distance? _____

8. A 50mm lens with the subject at fifteen feet would produce the same image size as a _____mm lens with the subject distance at thirty feet.
9. What are the three classifications of photographic lenses? _____

10. The angle of view will increase as the focal length _____.
11. Write in the angle of view in degrees for the below listed lenses.
 - a. Wide angle of short focal length = _____
 - b. Normal focal length = _____
 - c. Telephoto or long focal length = _____
12. Name the two dimensions which objects are reproduced on the focal plane?

13. Depth perspective is dependent on what? _____

14. Which lens focal length type causes objects in the background to appear closer to objects in the foreground? _____
-

ANSWERS TO PRACTICE EXERCISE

1. Optical Center, Lesson 2/Learning Event 1
Para 1b.
2. Focal plane, Lesson 2/Learning Event 2
Para 1.
3. Infinity, Lesson 1/Learning Event 1
Para 1c.
4. Infinity, Lesson 1/Learning Event 1
Para 1c.
5. Focal length, Lesson 2/Learning Event 1
Para 1.
6. Focal length, Lesson 2/Learning Event 2
Para 1.
7. A lens twice the focal length, Lesson 2/Learning Event 2
Para 3.
8. 100mm, Lesson 2/Learning Event 1
Para 1.
9. Wide angle or short focal length, normal or normal focal length, and
telephoto or long focal length.
Lesson 2/Learning Event 2
Para 3.
10. Decreases, Lesson 2/Learning Event 4
Para 1.
11. a. Less than 45 degrees
b. 45 to 55 degrees
c. More than 55 degrees
Lesson 2/Learning Event 3
Para 4.
12. Height and width, Lesson 2/Learning Event 4
Para 1.
13. Lens to subject distance, Lesson 2/Learning Event 4
Para 5.
14. Telephoto or long focal length, Lesson 2/Learning Event 4
Para 2.

LESSON 3
APPLY THE FUNDAMENTALS OF EXPOSURE AND FOCUSING

TASK

Calculate, determine, identify, and select the methods and the application of the fundamentals of exposure and focusing.

CONDITIONS

Given information about the light sensitivity of film, common types of mechanical shutters, shutter durations, aperture openings, daylight exposure, depth of field, hyperfocal distance, and focusing.

STANDARDS

Demonstrate competency of the task skills and knowledge by responding to the multiple-choice test covering fundamentals of exposure and focusing.

REFERENCES

TM 11-401, TM 11-401-1, TM 11-6720-253-10

Learning Event 1: DETERMINE THE LIGHT SENSITIVITY OF FILM

1. Exposure depends on the intensity of the light and the amount of time the light exposes light sensitive material. Light sensitive material consists of silver halides bonded in gelatin called the emulsion. This emulsion layer is supported by a base. The base material is made of either film, glass or paper.

2. Photographic film comes in many different sizes, types, and formats. All films are assigned a numerical value indicating its sensitivity to light. This numerical value is referred to as "ISO" (International Standards Organization). ISO is a numerical value indicating an emulsion's specific degree of sensitivity to light, referred to as the film speed.

a. The most commonly used ISO numbers range from 25 to 400. The higher the number the more sensitive the film, which means less light is needed for proper exposure. The lower the number the less sensitive the film, which requires more light for proper exposure.

b. For convenience, the ISO numbers are usually classified into three

categories: slow speed (ISO 25 to 32), medium speed (ISO 50 to 125), and high speed (ISO 160 to 400).

c. Higher speed films of more than ISO 400 are attainable on the market today which are ultra high speed films.

d. A doubling of the ISO number indicates a doubling of the sensitivity of the film. Thus, a film with an ISO of 400 rating needs only one half the amount of light for proper exposure than a film rated at ISO 200. Conversely, a film rated at ISO of 100 is half as fast or sensitive as a film rated at ISO 200 and requires twice the amount of light for a proper exposure.

Learning Event 2:

IDENTIFY THE TWO COMMON TYPES OF MECHANICAL SHUTTERS

1. The camera shutter is an adjustable mechanism that can be opened and closed for a predetermined length of time to regulate the duration that light is permitted to pass through the lens and expose the film. There are two types of shutters commonly used. They are the focal plane shutter and the between the lens (leaf type) shutter. A focal plane shutter is a curtain made of cloth or metal.
2. The selection of a shutter speed determines the slit width of the curtain and the speed the slit travels across the film plane. Different slit widths and different speeds of travel across the film plane provides several different shutter speeds.
3. The focal plane shutter of modern 35mm cameras have two curtains. A slit of different widths is created by delaying the movement of the second curtain in relation to the first (fig 3-1).

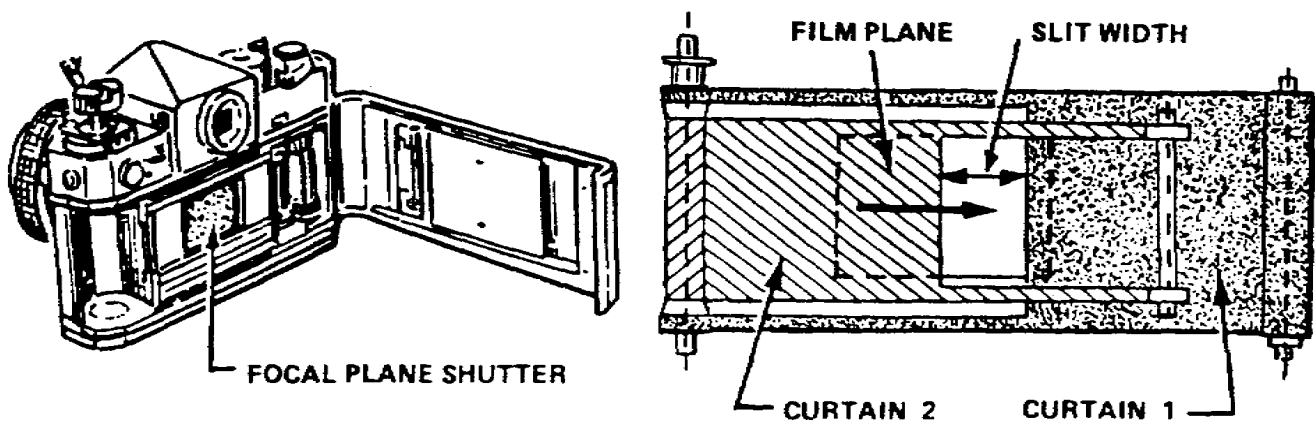


Figure 3-1. Focal plane shutter

4. A between the lens shutter consists of thin metal blades activated by springs. The selection of a shutter speed determines the duration of time the blades are opened (fig 3-2).

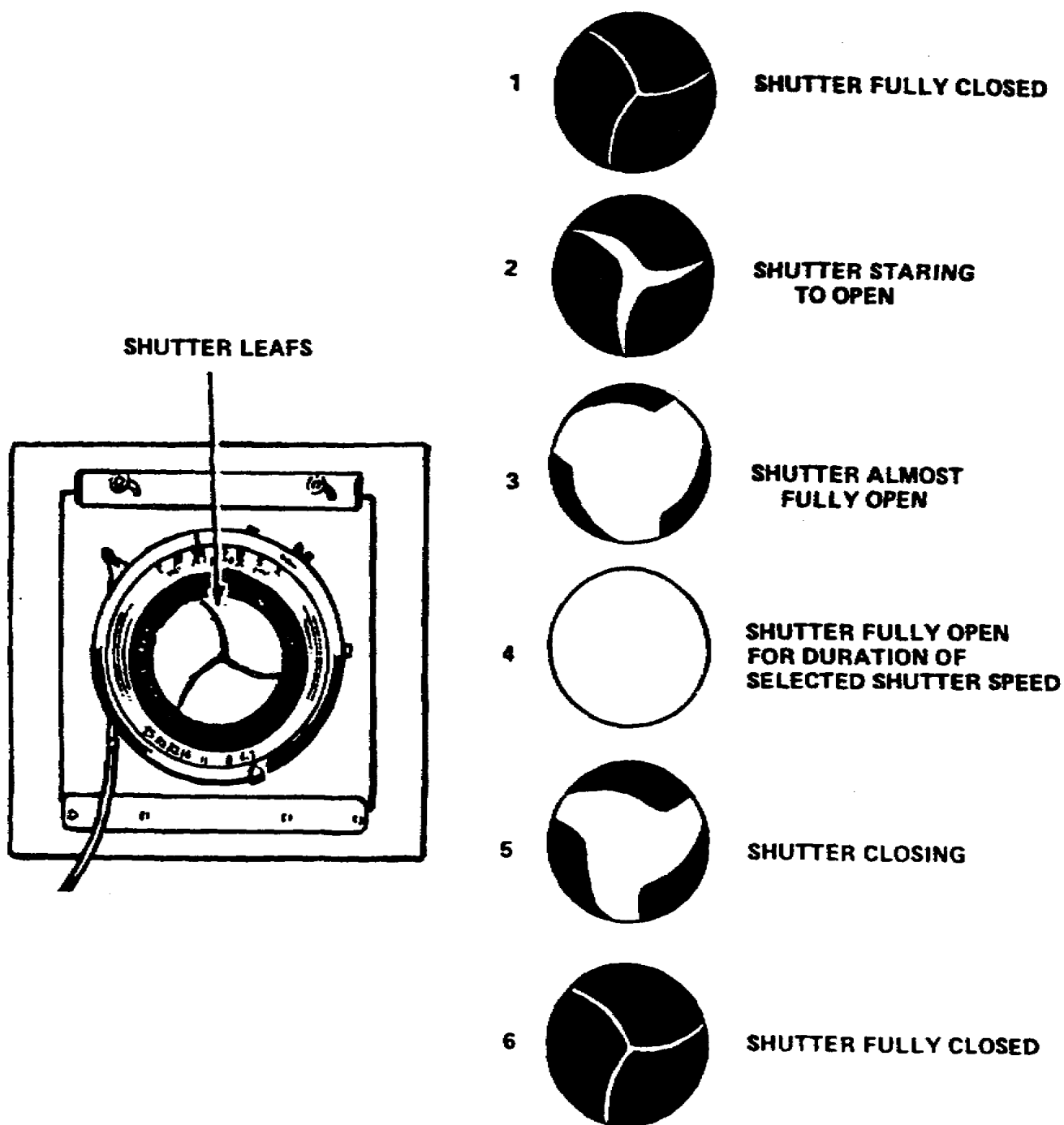


Figure 3-2. Between the lens leaf shutter

Learning Event 3
CALCULATE SHUTTER DURATION

1. The shutter controls the length of time light is allowed to react on the light sensitive material. This time is divided into fractions of a second, known as shutter speeds. Shutter speeds are usually written as fractions such as $1/125$, $1/250$ and so on. The appearance of the action in a photograph can be controlled by using different shutter speeds. A fast shutter speed will freeze, or stop the action. Where as a slow shutter speed will help create the illusion of motion. Shutter speeds will vary based on the amount of available light, and the speed of a moving subject. The most common shutter speeds available for modern cameras are: T (time), B (bulb), 1 second and fractions of a second of: $1/2$, $1/4$, $1/8$, $1/15$, $1/30$, $1/60$, $1/125$, $1/250$, $1/500$, $1/1000$ and $1/2000$.

a. By using the setting marked "T" (time), the shutter will open when pressure is applied to the shutter release button and will remain open until pressure is again applied to the shutter release button. This setting is normally used for exposure times that require minutes or even hours and allows you to leave the camera in place during exposure until you return at a time you selected to reapply pressure to the shutter release button.

b. On the setting marked "B" (bulb), the shutter will open when pressure is applied to the shutter release button and will remain open until the pressure is released. This setting is normally used for exposure times requiring two or more seconds. Once pressure is released from the shutter release button the shutter will close. Use of a tripod is required for exposures of "T" and "B" as the camera must remain motionless during exposure.

c. The remaining shutter speed selections re a full one second and fractions of a second. Changing shutter speed to the next indicated speed will either double the duration of shutter opening or decrease the duration of shutter opening by one half. For example, if a shutter speed of $1/60$ allows one unit of light to pass through, then the next slower shutter speed of $1/30$ will allow two units of light to pass through. A shutter speed of $1/125$ will allow one half as much light or one half of a unit of light to pass through than $1/60$.

2. Shutter speeds are referred to as faster or slower shutter speeds as related to each other. Thus, $1/250$ is a faster shutter speed than $1/125$ and below, but slower than, $1/500$ and above. It is proper to say that $1/250$ is two times faster and allows one half the amount of light as $1/125$ and $1/60$ is one half slower and allows two times the amount of light as $1/125$. Therefore, if a $1/500$ allows one unit of light, $1/250$ will allow two units of light (two times more), $1/125$ will allow four units of light (four times more), and $1/60$ will allow eight units of light (eight times more) as $1/500$. Notice that each change in shutter speed allows two times (2X) more or 1/2 less light (see table 3-1).

		NEW SHUTTER SPEED											
		1 sec	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250	1/500	1/1000	1/2000
O L D S H U T T E R S P E E D	1 sec												
	1/2	2											
	1/4	4	2										
	1/8	8	4	2									
	1/15	16	8	4	2								
	1/30	32	16	8	4	2							
	1/60	64	32	16	8	4	2						
	1/125	128	64	32	16	8	4	2					
	1/250	256	128	64	32	16	8	4	2				
	1/500	512	256	128	64	32	16	8	4	2			
	1/1000	1024	512	256	128	64	32	16	8	4	2		
	1/2000	2048	1024	512	256	128	64	32	16	8	4	2	
		INCREASE LIGHT											

Table 3-1. Effect of increase or decrease in exposure

Learning Event 4
CALCULATE APERTURE OPENINGS

1. The aperture diaphragm is an adjustable device made of thin, curved, metal blades which overlap each other which function much like the iris of your eyes (fig 3-3). The aperture controls the intensity of the light, through the lens.

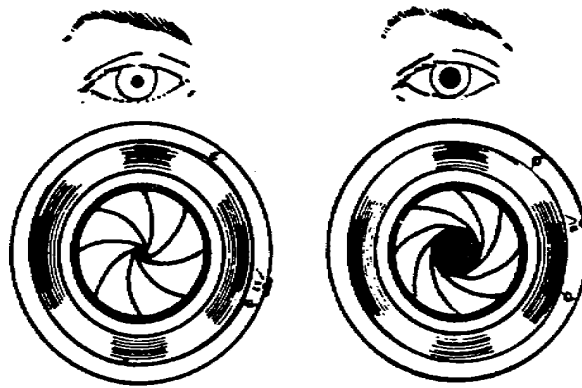


Figure 3-3. Iris and iris diaphragm (aperture)

a. The diameter of the diaphragm opening is controlled by the aperture ring which is scaled in increments referred to as f/stops. Rotating the aperture ring in the direction that reduces the diameter of the diaphragm opening is referred to as stopping down and moving the aperture ring in the direction which increases the diameter of the diaphragm opening is referred to as opening up.

b. When the diaphragm is set at the largest aperture, the lens is said to be wide open. This largest opening is the maximum working aperture of the lens and is called the lens speed or speed of the lens. The lens speed of any lens is determined by dividing the lens focal length by the diameter of the lens. A lens with a focal length of 100mm and a lens diameter of 25mm will result in a lens speed of 4. The largest opening and lens speed of this lens is expressed as f/4.

FL - focal length FL = 100mm

D - lens diameter ----- = F/4

D = 25mm

2. The f/system is a factorial system devised for the marking of the f/value of the many different lens aperture sizes possible. These f/value markings are found on the aperture ring and are referred to as f/stops. The f/value is determined by dividing the diameter of the diaphragm opening by the lens focal length. Thus a lens set at f/8 means that the diameter of the diaphragm opening is 1/8th of the lens focal length. F/16 would be a lens diaphragm diameter opening of 1/16th of the lens focal length. As the f/stop increases in size the diameter of the diaphragm decreases in size and visa-versa (fig 3-4).

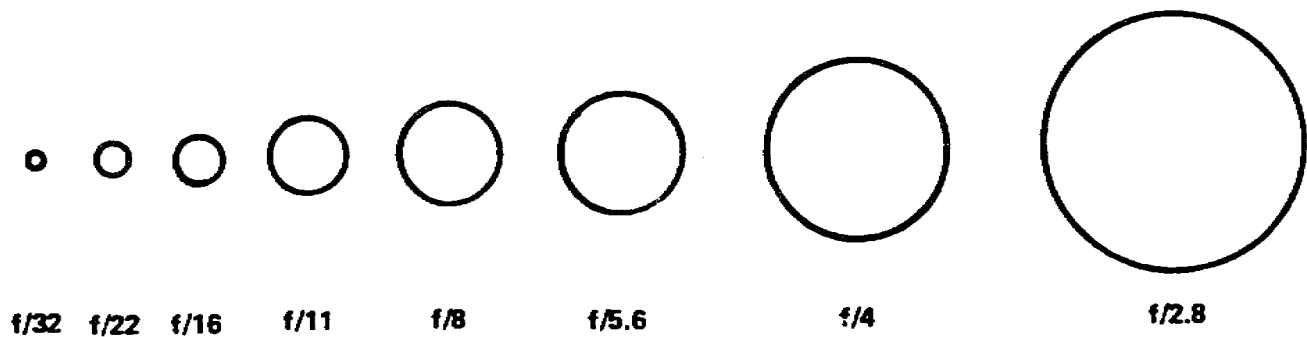


Figure 3-4. Relative size of various f/stops

a. Changing from one f/stop to the next will either double or half the intensity of light passing through the lens. Thus f/8 allows twice the amount of light as f/11 and half the amount of light as f/5.6.

b. As with shutter speeds, f/stops have the same halving and doubling effect on the amount of light. Shutter speeds control the duration time and f/stops control the intensity of light. Table 3-2) demonstrates the different values of light intensity relative from one f/stop to another.

		NEW F/STOP										
		f/1.4	f/2	f/2.8	f/4	f/5.6	f/8	f/11	f/16	f/22	f/32	
O L D F / S T O P	f/1.4		1/2	1/4	1/8	1/16	1/32	1/64	1/128	1/256	1/512	D E C R E A S E I N T E N S I T Y
	f/2	2		1/2	1/4	1/8	1/16	1/32	1/64	1/128	1/256	
	f/2.8	4	2		1/2	1/4	1/8	1/16	1/32	1/64	1/128	
	f/4	8	4	2		1/2	1/4	1/8	1/16	1/32	1/64	
	f/5.6	16	8	4	2		1/2	1/4	1/8	1/16	1/32	
	f/8	32	16	8	4	2		1/2	1/4	1/8	1/16	
	f/11	64	32	16	8	4	2		1/2	1/4	1/8	
	f/16	128	64	32	16	8	4	2		1/2	1/4	
	f/22	256	128	64	32	16	8	4	2		1/2	
		f/32	512	256	128	64	32	16	8	4	2	
INCREASE INTENSITY												

Table 3-2. The increase or decrease of light intensity from one f/stop to another

Learning Event 5

CALCULATE SHUTTER SPEED, APERTURE, AND FILM SPEED

1. Shutter and aperture control exposure. The shutter speed controls the length of time light exposes the film and the aperture controls the intensity of the light exposing the film. Both the shutter and aperture have a doubling and halving effect upon exposure.

2. There are many combinations of shutter speeds and f/stops which will have the same relative exposure, for example, 1/125 at f/16 has the same relative exposure as 1/250 at f/11 because 1/250 is one half the duration of 1/125 and allows one half the amount of light and f/11 has twice the aperture diaphragm area as f/16 and doubles the intensity of light exposing the film. Thus, the result is an equal exposure of both combinations.

3. Column a, b, and c are examples of different shutter speed and f/stop combinations which will result in the same exposure.

A	B	C
1/60 @ f/16	1/125 @ f/16	1/500 @ f/4
1/125 @ f/11	1/250 @ f/11	1/250 @ f/5.6
1/250 @ f/8	1/500 @ f/8	1/125 @ f/8
1/500 @ f/5.6	1/1000 @ f/5.6	1/60 @ f/11

4. As stated previously, the ISO is a numerical value indicating the film's degree of sensitivity to light. The more sensitive a film is to light, the less exposure is required and visa-versa.

5. If you load a camera with film having an ISO of 100 and you are photographing a subject with an effective exposure of 1/125 at f/8 and then reloaded the camera with film rated at ISO 50, the effective exposure for the same subject would have to be changed to 1/60 at f/8 or 1/125 at f/5.6 because the film rated at ISO 50 is one half as sensitive to light as ISO 100. If the film change was to a film rated at ISO of 200 from ISO of 100, then the new effective exposure for the same subject would be 1/250 at f/8 or 1/125 at f/11 because the film speed of ISO 200 is twice as sensitive to light as ISO of 100.

6. The chart below is an example of ISO ratings, shutter speed and f/stop combinations that will yield the same effective exposure.

FILM SPEED EFFECTIVE EXPOSURE

ISO 25 1/60 @ f/4	or	1/125 @ f/2.8
ISO 50 1/125 @ f/4	or	1/60 @ f/5.6
ISO 100 1/250 @ f/4	or	1/60 @ f/8
ISO 200 1/500 @ f/4	or	1/60 @ f/11
ISO 400 1/1000 @ f/4	or	1/60 @ f/16

Learning Event 6

DETERMINE DAYLIGHT EXPOSURE

1. Exposure. Exposure calculations for exposing film under daylight conditions are the intensity, direction and color quality of the daylight. (The later for color films).

a. Intensity. From early morning until late evening, even on a clear day, the intensity of daylight is constantly changing as the sun rises. The intensity of daylight varies throughout the day, the time between about two hours after sunrise until about two hours before sunset is considered a time when the light intensity in a specific location remains constant for exposure purposes.

b. Bright Sun on Light Sand or Snow. Bright sun is daylight unhampered by an apparent atmospheric barriers. Because of the amount of reflected light from sand or snow, the intensity of light in such a scene is greater than that of a scene with average reflectance. This greater intensity of light requires a decrease in f/stop or a faster shutter speed to provide approximately one-half the exposure required for the basic exposure with bright sun.

c. Bright Sun (Distinct Shadows). Daylight exposure recommendations for a specific film are based on the exposure required for an average scene in bright sun conditions. This exposure is termed the BASIC EXPOSURE.

d. Hazy Sun (Soft Shadows). A weak, hazy sun is the result of a heavier or thicker haze or cloud cover as compared to the bright sun (distinct shadows) condition, this condition causes a decrease in the daylight intensity and an increase in the diffusion of daylight to a degree where shadows are soft or indistinct. To compensate for this decreased daylight intensity, a larger f/stop or slower shutter speed is required to approximately double the basic exposure.

e. Cloudy Bright (No Shadow). Cloudy bright is a result of a layer of clouds which further reduces the intensity of daylight and completely diffuses the light. In a cloudy bright condition the position of the sun can be located as a bright area in the clouds. A compensation of four times (two stops or four times longer shutter speed) the basic exposure is required for the decreased intensity of light.

f. Heavy Overcast. This condition is prevalent when the position of the sun cannot be located. The scene brightness range is low and therefore photographs made during heavy overcast conditions usually lack contrast. A compensation of eight times the basic exposure is required for the decreased intensity of light.

g. Open Shade. Open shade occurs when an average scene is shaded from a bright or hazy sun. For a subject to be considered in open shade, objects such as a porch roof or tree limbs must not overhang the scene, and at least 60 degrees of unobstructed sky must be overhead and in front of the scene. Usually, open shade requires the same exposure as heavy overcast conditions (fig 3-5).

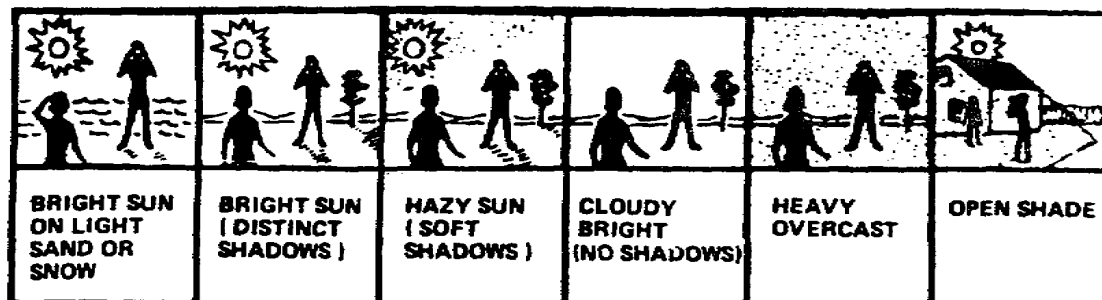


Figure 3-5. Daylight conditions

2. Direction. The exposure setting recommended for films exposed during the daylight conditions of bright or hazy sun on light sand or snow, bright sun (distinct shadows), and hazy sun (soft shadows) are for scenes which are front lighted only. With the cloudy bright (no shadows), heavy overcast, and open shade conditions, the direction of the light is not apparent because of the diffusion of the daylight.

a. The amount of daylight reflected from a scene can vary when the direction of the light is changed in relation to the direction the camera is pointed. A scene appears brightest and reflects the most light to the camera when the light source is behind the camera.

b. Whenever light originating from behind the camera falls upon a scene, it is termed from lighting. As the camera is moved in an arc around the scene, more shadow area in the scene is presented. Therefore, less light is reflected from the scene.

c. Whenever the light source is in an approximate 90 degree position in relation to the camera, the light falling upon the scene is termed side lighting. As the camera continues to move in the arc, a decrease in the amount of reflected light to the camera continues until the scene is directly between the camera and the light source.

d. With this camera position a large area of the scene will be in shadow resulting in the greatest decrease in reflected light to the camera. Light falling upon the scene with the camera in this position in relation to the light source is termed back lighting.

e. When the light reflected from the scene decreases as the direction of the light changes in relation to the camera, a compensation in exposure is required. Recommendations on the compensation for this decrease in light vary. However, as a general guide photographs of side lighted scenes usually require an increase of two times (one f/stop) the basic front light exposure, and photographs of back lighted scenes usually require four times (two f/stops) the Basic front light exposure. The final determination of increased exposure required to compensate for side or back lighting is the amount of shadow detail desired in the photograph (fig 3-6).

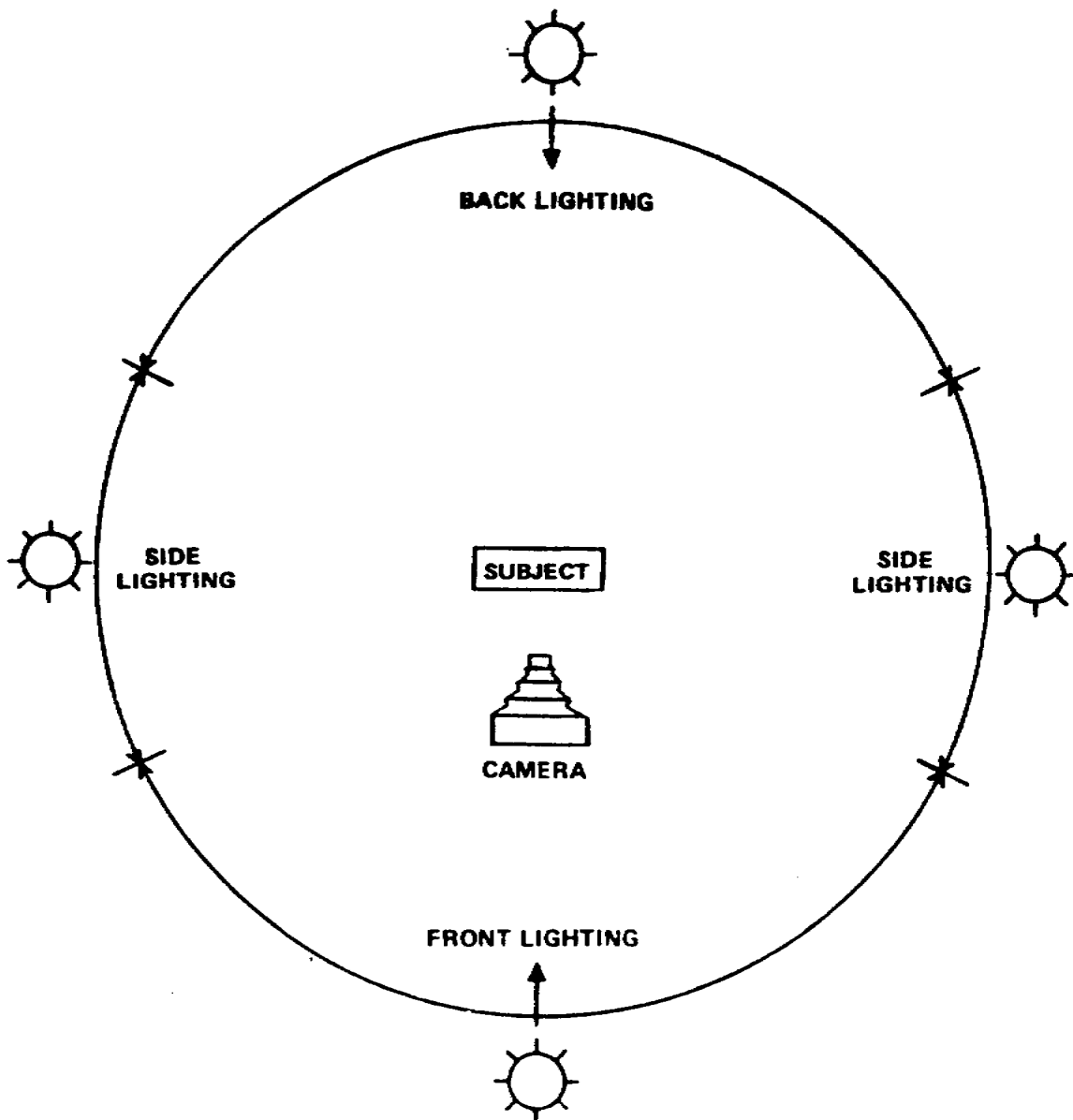


Figure 3-6. Lighting directions

f. A silhouette effect (no shadow detail of a back lighted scene can be produced by using a diaphragm opening approximately one full f/stop smaller than the f/stop required for the basic front light exposure for the scene. For example, if the basic front light exposure is f/16, use r/22 to produce a silhouette of the back lighted subject.

3. Color and Shades of Objects in a Scene. Not all the light which falls upon the surface of an object is reflected. A brilliant white object reflects a great percentage of light while a deep-black object reflects very little of the light between these two extremes are the numerous tones of gray and the visible colors in their various hues and brightnesses.

a. Each colored or gray object in a scene reflects a specific amount of light. A scene which consists primarily of light-colored or light-toned objects will usually require a decrease in exposure as compared to the basic exposure for an average scene.

b. Conversely, a scene which consists primarily of dark-colored or dark-toned objects will usually require an increase in exposure as compared to the basic exposure for an average scene. The primary reason light scenes and dark scenes require less exposure and more exposure, respectively, in comparison to an average scene is to maintain detail in the highlights of the light scenes and detail in the shadow areas of the dark scenes.

c. So classifications of dark, normal and light are determined from the colors and shades of objects in a scene. With dark objects requiring an increase of exposure of one f/stop, normally require no change, and light objects requiring a decrease of exposure of one f/stop.

4. Test Exposure. The best way to ensure a correct exposure under all of these differing lighting conditions is to make test exposures. However, if exposure tests are not practical prior to making a photograph, a technique termed exposure bracketing can be used. Exposure bracketing is the exposing of film in a series of increasing or decreasing exposures, usually in increments of one-half or full f/stops. One of the exposures in the series of bracketed exposures should yield acceptable results.

Learning Event 7

CALCULATE DAYLIGHT EXPOSURE

1. A system of calculating outdoor daylight exposure without the aid of a photoelectric exposure meter (light meter) is necessary for determining a proper exposure for the various daylight condition, subject reflectance, lighting direction, and film sensitivity. The f/16 rule, an established practice in the Army and among many professional photographers, has been proven to be an accurate approach for the calculation of daylight exposure. Many photographers use this rather than using their light meters. There are three good reasons why photographers do not rely on the automatic built-in exposure meters in their cameras. First, the photographer wants to control the exposure for a desired effect instead of the camera controlling it. Second, exposure meters can't think; it does not know what the photographer's intentions are for, in the finished photograph. Third, exposure meters are mechanical and subject to failure. They can be inconsistent, consistently wrong, or fail all together. Knowledge and practice of the f/16 rule will enable you to spot when the exposure meter is lying. This could mean the difference between the success or failure of your assignment.

2. The f/16 rule is based on the basic exposure norms and the ISO. The basic exposure norms are: bright sun, front lighting, and average subjects which are all based on f/16. Hence the term "BASIC EXPOSURE." To complete the rule, set the shutter speed to match, or nearly match, the film's ISO speed rating, for example, ISO 125 and 100 set the shutter speed at 1/125, for ISO 50 and ISO 64, set the shutter speed at 1/60.

a. The procedure then is to change the basic exposure (f/16 for each daylight condition as follows:

Bright sun on light sand or snow; f/22
 Bright sun (no change); f/16
 Hazy sun, soft shadows; f/11
 Cloudy bright, no shadows; f/8
 Heavy overcast; f/5.6
 Open shade; f/5.6

b. And correct for subject brightness:

Light (bright) subjects, stop down one stop.
 Average subjects (no change).
 Dark subjects, open one stop.

MATCH SHUTTER SPEED TO FILM SPEED			
Daylight Conditions	SUBJECT BRIGHTNESS		
	Light/Bright Subjects	Average Subjects	Dark Subjects
Bright sun (on light sand or snow)	f/32	f/22	16
Bright sun	f/22	f/16	11
Hazy sun	f/16	f/11	8
Cloudy bright (no shadows)	f/11	f/8	5.6
Overcast or open shade	f/8	f/5.6	4

Table 3-3. Match shutter speed to film speed

c. Now correct the basic exposure for lighting directions:

Front lighting (no change)

Side lighting, open up one additional stop

Back lighting, open up two additional stops for close-ups

3. In each case, start with the ISO speed to determine the shutter speed, set f/16 as your lens aperture, and open up or stop down by the required number of stops for the lighting conditions, subject brightness and lighting direction. Take a bright subject which is side-lit on a day with hazy-sun. What would the effective exposure be using a film rated at ISO 200?

a. By starting with the ISO, set the shutter speed for 1/250 as this closely matches the ISO of 200. Preset the f/stop at f/16 and determine the lighting conditions; hazy-sun requires the aperture to be opened up one stop from the basic exposure, so open the aperture to f/11.

b. Now correct for subject brightness; a bright subject requires the aperture to be stopped down one stop. Change the aperture from f/11 to f/16. And last, correct for lighting direction; side-light requires you to open one stop. Open the aperture one stop from f/16 to f/11. The effective exposure will be 1/250 at f/11.

c. Now if you wish, you can select any exposure combination which would equal the effective exposure of 1/250 at f/11. For example, 1/125 at f/22,

1/500 at f/8 and so on.

4. With the practice of the f/16 rule, you will find that determining and setting the effective exposure will become second nature to you and you will be using a light meter only as a tool and not as a crutch.

Learning Event 8

DEFINE FOCUS

1. When a lens is focused on a point, only that point in the geometric plane, without depth, is in true sharp focus. The law of physics allows depth to be added to this plane in various degrees as determined by the lens focal length, f/stop , distance focused on, and the permissible size of the circle of confusion.

2. Circle of Confusion. The focus of an image on the focal plane film plane is determined by the size of the circle of confusion. Basically, an image is an accumulation of many points. For example, light is reflected from a subject, refracted by the lens and reproduced on the focal plane as circles.

a. Light rays seem to produce a "cone" of light " (fig 3-7). The apex of the cone originates at a point on the subject; the base of the cone is at the lens. When light rays pass through the lens, the cone of light is reversed. The base is still at the lens, but the apex now lies in the focal plane. An infinite number of these cones combine to produce an image.

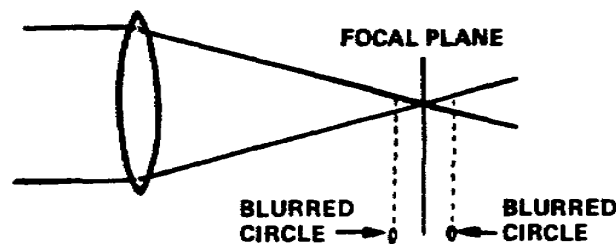


Figure 3-7. Circle of confusion

b. The smallest circle of confusion should intersect at the focal plane for the best acceptable sharpness. If the cone of light intersects either in front or behind the focal plane, the light rays form circles rather than points. These are called circles of confusion. When the circles are small enough, they are said to be acceptably sharp to the eye and are in focus.

c. If you find circles of confusion perplexing, take a camera and focus on a point. Now turn the focusing ring and you will notice that the point enlarges and becomes out of focus. The more the point enlarges, the more out of focus it becomes. Now turn the focusing ring to bring the point back into focus and notice the point decreases in size back to normal as it becomes more focused.

d. You are not expected nor required to carry a ruler around and do measurements on circles of confusion to determine if a photograph is in focus or not. Everyone will have a different acceptance of what is sharp focus. However, if the circle is smaller than $1/100$ inch on the print, it appears as a sharp point to the eye. If the circle is larger than $1/100$ inch, their eyes see it as a circle and the image is blurred or out of focus.

e. The size of the permissible circle of confusion depends on the film format size and the manner in which the film will be used. The generally

accepted circles of confusion are given in Table 3-4 below.

Film Size	Diameter (inches)	
16mm	0.001	1/1000
35mm	0.002	1/500
2 1/4 x 2 3/4	0.004	1/250
4 x 5	0.006	1/150
Permissible Circle of Confusion		

Table 3-4.

f. The smaller the film size the smaller must be the circles of confusion. Since small film must be enlarged in order to produce usable print, that small circle of confusion will also enlarge. As an example, take a 35mm negative. It has a usable area of 24mm by 36mm (about 1" by 1 7/16") (fig 3-8). When this area is enlarged or projected on a screen it will have been "enlarged" anywhere from 4 to 40 diameters. Consider that a 4- by 6-inch print is roughly a 4 diameter enlargement of a 35mm negative. If you projected a 35mm slide on a 40-inch by 60-inch screen, your "enlargement" is about 40 diameters. In other words that very small circle of confusion is now about 40 times bigger when viewed on a screen. This is why CoC and focus are important to a photographer.

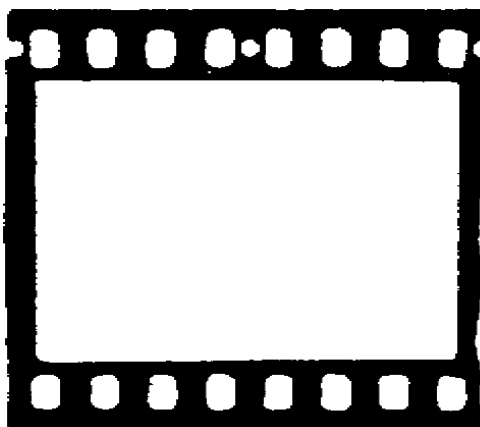


Figure 3-8. 35mm Frame

Learning Event 9

DEFINE DEPTH OF FIELD AND HYPERFOCAL DISTANCE

1. Depth of Field. Depth of field is the distance from the nearest point (NP) of acceptable sharpness to the furthest point (FP) of acceptable sharpness.

a. When a lens is focused on a nearby object, the depth of field is short. If the distance setting is increased, the depth of field increases. This is the reason why it is important to focus more accurately for nearby objects than for distant objects, when focusing a lens so several objects that are at different distances, best results are obtained by focusing on a point one third into the distance between the nearest and farthest point. Depth of field always ranges from one-third before to two-thirds after the point focused on (fig 3-9).

b. Depth of field can be computed mathematically or determined by the depth of field indicator found on the lenses on modern 35mm cameras.

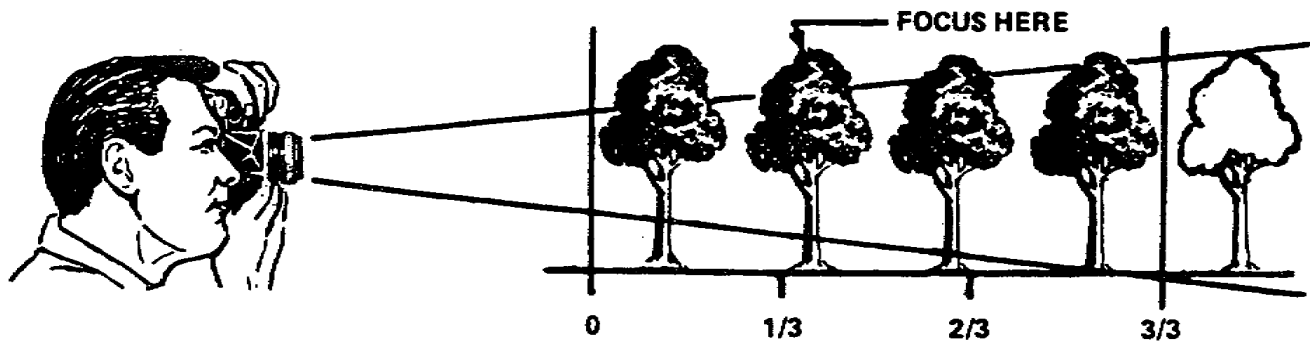


Figure 3-9. Depth of field

2. Hyperfocal Distance. Hyperfocal distance is the distance from the LENS to the NEAREST POINT of acceptable sharpness when the lens is FOCUSED at INFINITY.

a. Applying the hyperfocal distance, a special case of depth of field is achieved. Example, when a lens is focused at infinity, the depth of field will range from the hyperfocal distance, which is at the nearest point of focus, to infinity.

b. This depth of field can be extended by refocusing the lens at the hyperfocal distance. This will move the nearest point of acceptable sharpness to one half the distance of the point focused on. The depth of field has now been extended to one half the hyperfocal distance to infinity. If the hyperfocal distance happens to be 12 feet and the lens is focused at 12 feet, the depth of field would be from 6 feet to infinity (fig 3-10).

c. Hyperfocal distance always includes infinity. Depth of field may or may not include infinity.

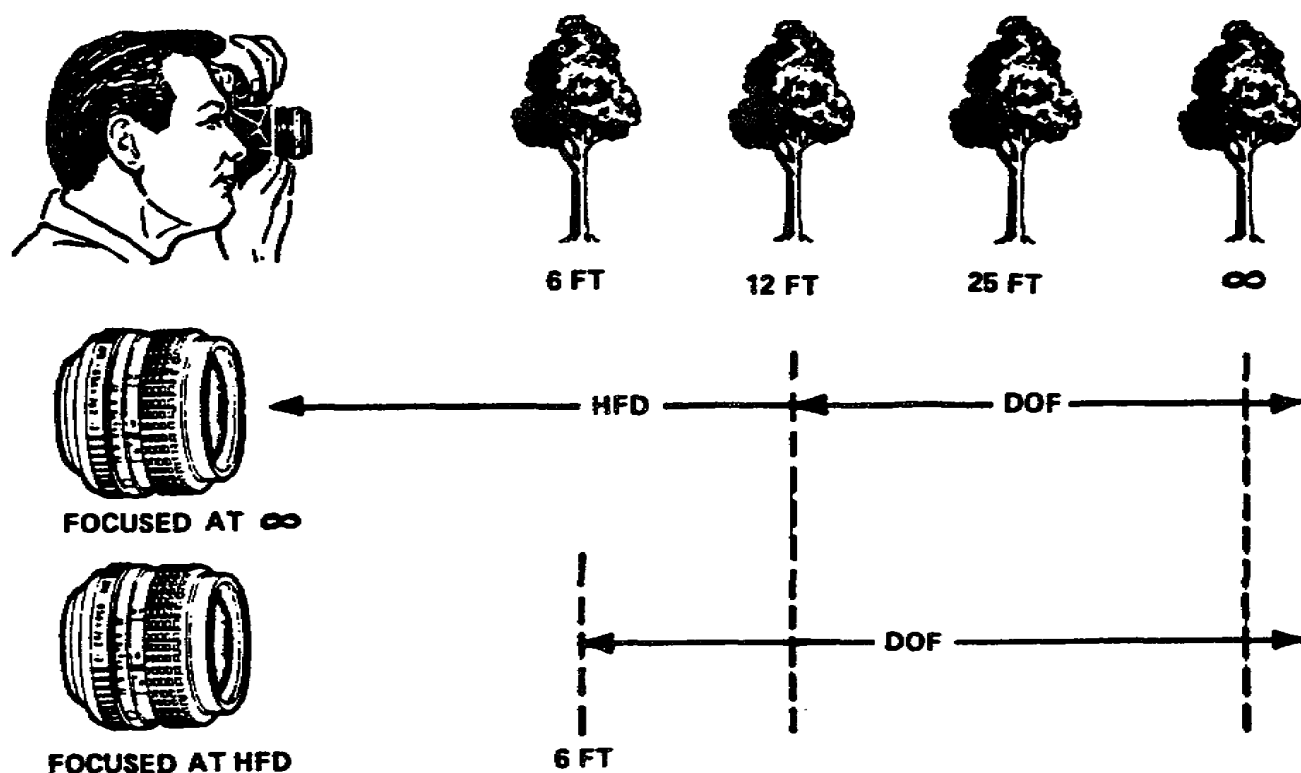


Figure 3-10. Depth of field and hyperfocal distance

Learning Event 10
CALCULATE HYPERFOCAL DISTANCE

1. The hyperfocal distance varies with focal length, f/stop, and the permissible size of the circle of confusion. The following formula is used for computing hyperfocal distance. NOTE: Numerical values for the formula must all be expressed in inches or millimeters. For this lesson, the formula will be expressed in inches.

a. For non-scientific purposes, 25mm equals 1 inch, 50mm equals 2 inches, etc.

- (1) HFD - Hyperfocal Distance
- (2) FL^2 - Focal Length, Squared

NOTE: To square a number you multiply it by itself.

- (3) F - f/stop
- (4) CoC - Circle of Confusion
- (5) 12 - Convert to feet

b. The formula is written as:

$$HFD = \frac{FL^2}{f \times CoC \times 12}$$

of

$$\text{Hyperfocal Distance} = \frac{\text{Focal Length, Squared}}{\text{f/stop times Circle of Confusion times 12}}$$

c. Using a 35mm camera (which has a permissible Circle of Confusion of .002) with a 50mm lens focused at Infinity, and an aperture of f/8, the formula is expressed as:

$$\frac{2^2}{8 \times .002 \times 12} = \frac{4}{.192} = 20.8$$

- (1) The 50mm focal length lens is converted to 2 inches.
- (2) The aperture is f/8.
- (3) The Circle of Confusion for a 35mm format is .002 inches.
- (4) The 12 in the formula converts inches into feet.
- (5) The hyperfocal distance works out to be 20.8 feet. When the lens is refocused at 20.8 feet, the depth of field will extend from 10.4 feet to infinity.

Learning Event 11
SELECT APPROPRIATE FOCUS

1. Focusing on the hyperfocal distance is useful for the greater depth of field needed when photographing subjects where you have no control of their action, such as tactical sports, news events, and other documentary photography. When applying this technique, you have already preset the shutter speed, f/stop, and focused on the hyperfocal distance. This allows you to concentrate on the subject.

2. Focusing on the hyperfocal distance will not be practical at times when the subject is closer than one half the hyperfocal distance to the camera or when you may desire to apply selective focusing.

a. Selective focusing is a technique of limiting the depth of field in the foreground and the background in order to achieve a more vivid center of interest. This technique is commonly used for portraiture.

b. Application of selective focusing requires the knowledge of the controlling factors of depth of field.

c. Long depth of field can be obtained by using a short focal length (wide angle) lens, a small aperture opening, and a far point of focus. Conversely, a short depth of field can be obtained by using a long focal length (telephoto) lens, a large aperture opening, and a near point of focus.

d. Figure 3-11 shows the depth of field of wide angle and a telephoto lens. At the same aperture and focus point the wide angle (short focal length) lens will provide greater depth of field than a telephoto (long focal length) lens.

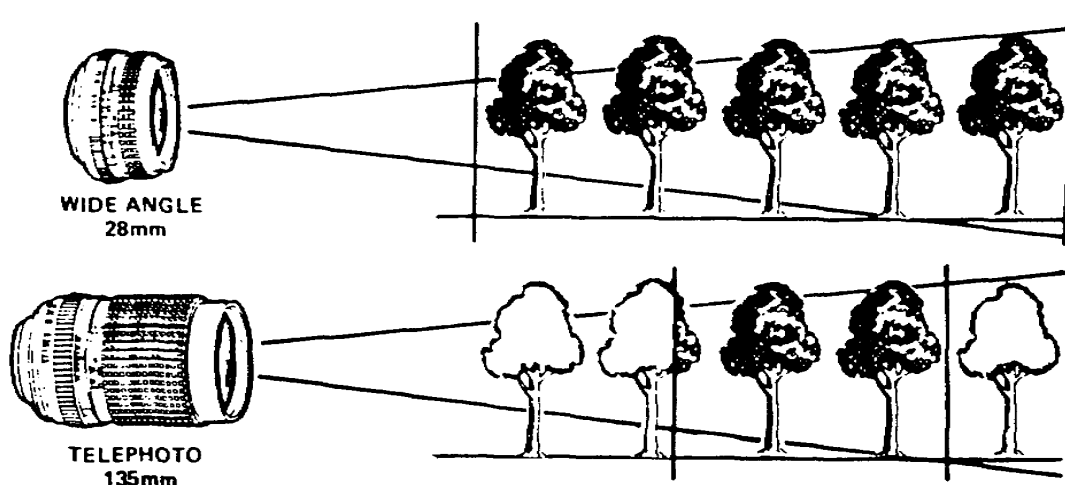


Figure 3-11. Depth of field

e. A small aperture (large f/stop number) will provide greater depth of field than a large aperture opening (small f/stop number) (fig 3-12).

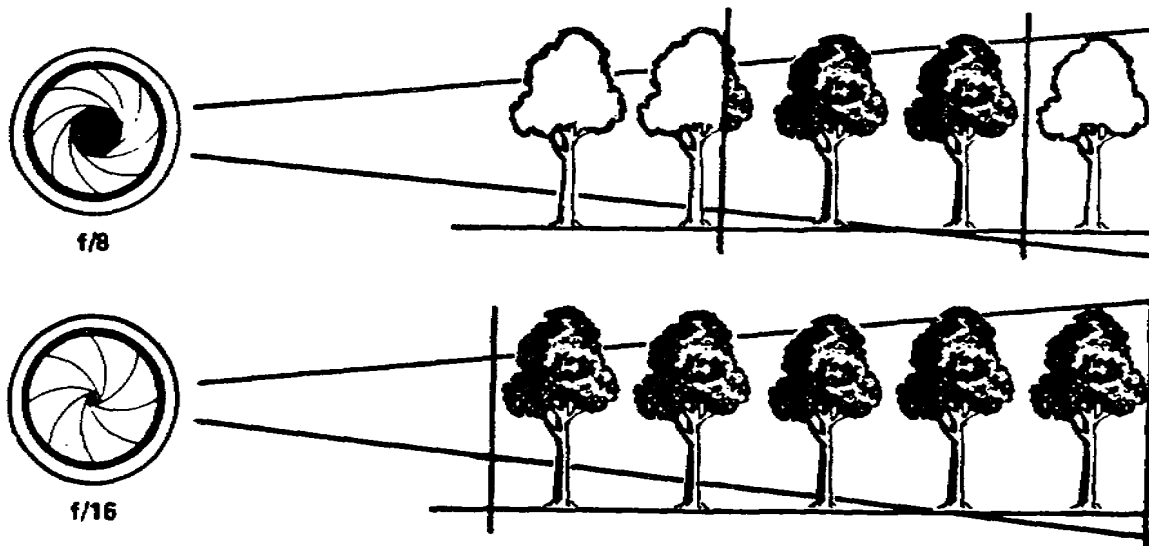


Figure 3-12. Depth of field increases as aperture decreases

Learning Event 12
CALCULATE DEPTH OF FIELD

1. To mathematically compute the range of the depth of field, the point which the lens is focused on and the hyperfocal distance is used for this calculation.

2. Using a 35mm camera, permissible Circle of Confusion of .002, with a 75mm lens, aperture set at f/8, and the lens focused at 15 feet, calculate the hyperfocal distance from the formula in para 3b.

a. The hyperfocal distance is 46.8 feet.

b. The near and far point of acceptable sharpness are determined using the following formula.

$$\frac{\text{HFD} \times \text{D}}{\text{HFD} + \text{D}} = \text{NP}$$
$$\frac{\text{HFD} \times \text{D}}{\text{HFD} - \text{D}} = \text{FP}$$

Hyperfocal Distance times Distance Focused on

Hyperfocal Distance plus Distance Focused on = Near Point

Hyperfocal Distance times Distance Focused on

Hyperfocal Distance minus Distance Focused on = Far Point

c. The formula is expressed as:

$$\frac{46.8 \times 15}{46.8 + 15} = 11.3 \text{ feet near point}$$
$$\frac{46.8 \times 15}{46.8 - 15} = 22 \text{ feet far point}$$

As shown from the formula above, the range of the depth of field is 10.7 feet because the nearest point of acceptable sharpness is 11.3 feet from the lens and the farthest point is 22 feet from the lens (22 feet minus 11.3 feet equals 10.7 feet). Always subtract the near point from the far point.

3. Depth of field scale. Experience will help you predict the best aperture to get the depth of field you want. But you do not have to guess the correct aperture all the time or use formulas.

a. Most lenses have a depth of field scale to guide you. This scale indicates the distance range in which the subjects will be in acceptable focus at different f/stops.

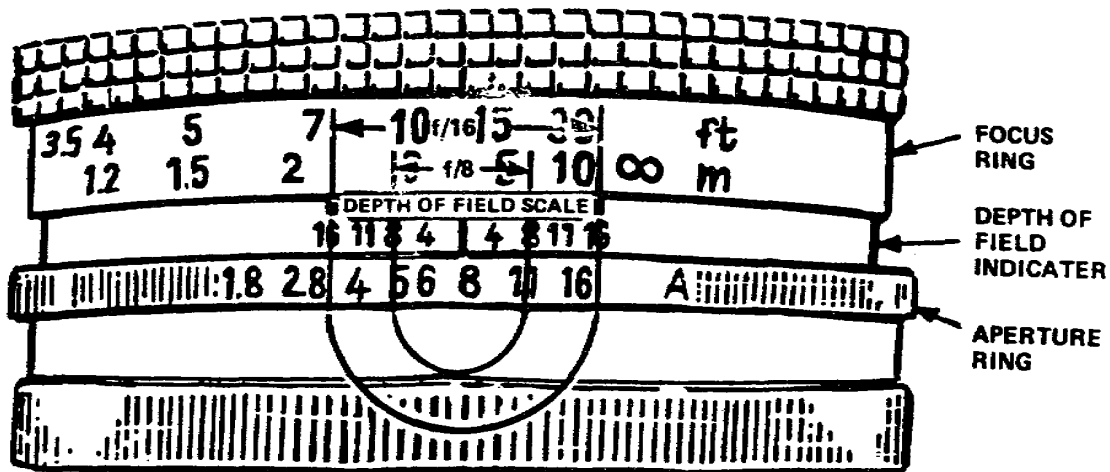


Figure 3-13. Depth of field scale

b. When this lens is focused at 13 feet, depth of field at f/8 ranges from about 7 to 22 feet. If used at f/16 depth of field would range from about 6 to 35 feet.

4. To use a depth of field scale:

a. Set the correct focusing distance for the subject by turning the focusing ring until the subject appears sharp in the viewfinder.

b. Set the aperture, make sure you set a usable shutter speed for correct exposure with the selected aperture.

c. Look at the depth of field scale and find the marks on it that correspond to the aperture you have set. On the depth of field scale there are two numbers for each corresponding lens aperture, one on either side of the scale center line.

d. As there are two corresponding numbers on the depth of field scale for the aperture you have set, read the two distances on the focusing ring which are opposite the two numbers on the depth of field scale. The subject will be in focus between these two points. Since exact measurements may not appear opposite the aperture numbers, you may have to estimate the distances.

PRACTICE EXERCISE

1. Exposure is dependent on the _____ of the light and the duration of the time that light is permitted to expose the film.
2. A film rated at ISO 200 is twice as sensitive to light than film rated at ISO of _____ and will require one/half the amount of light for a proper exposure.
3. What is the component that regulates the duration of exposure? _____

4. Due to the speed of the subject, a shutter speed which is 8 times faster than 1/60 sec is needed. What is the needed shutter speed? _____

5. What is the lens component which controls the intensity of the light permitted through the lens? _____

6. While outdoors the sun came from behind the clouds increasing the intensity of the daylight 8 times. Your present f/stop is 5.6, what should be the new f/stop? _____

7. The length of time light is allowed to expose the film is controlled by the _____ and the intensity of the light is controlled by the aperture.
8. Which daylight condition produces no shadows but the position of the sun can be located? _____

9. A light source at 90 degrees position in relation to the camera is referred to as what type of lighting? _____

10. You have set the shutter speed to match the ISO rating; what are the f/stops for the following lighting conditions?
 - a. Bright sun on light sane or snow _____.
 - b. Bright sun _____.
 - c. Hazy sun, soft shadows _____.
 - d. Cloudy bright, no shadows _____.

- e. Heavy overcast _____.
- f. Open shade _____.
11. Using film rated at ISO of 250, a shutter speed of 1/125, on a cloudy bright day, average subject, and side lit. What is the f/stop? _____
12. What is the permissible size of circle of confusion when using 35mm film? _____
13. _____ is the distance from the nearest point of acceptable sharpness to the farthest point of acceptable sharpness.
14. _____ is the distance from the lens to the nearest point of acceptable sharpness when the lens is focused at infinity.
15. What would be the range of depth of field when the lens is focused on the hyperfocal distance? _____
16. Using the hyperfocal distance formula, what is the hyperfocal distance to the nearest foot, using 35mm film, 50mm lens and an aperture setting of f/11? _____
17. What is the range of depth of field to the nearest foot with a lens focused at 20 feet and the hyperfocal distance at 56 feet? _____

ANSWERS TO PRACTICE EXERCISE

1. Intensity, Lesson 3, Learning Event 1, Para 1.
2. 100, Lesson 3, Learning Event 1, Para 2d.
3. Shutter, Lesson 3, Learning Event 2, Para 1.
4. 1/500, Lesson 3, Learning Event 3, Para 1.
5. Aperture, Lesson 3, Learning Event 4, Para 1.
6. f/16, Lesson 3, Learning Event 4, Para 2.
7. Shutter, Lesson 3, Learning Event 2, Para 1.
8. Cloudy bright, Lesson 3, Learning Event 6, Para 1e.
9. Side lighting, Lesson 3, Learning Event 6, Para 2c.
10.
 - a. f/22
 - b. f/16
 - c. f/11
 - d. f/8
 - e. f/5.6
 - f. f/5.6, Lesson 3, Learning Event 7, Para 2a.
11. f/8, Lesson 3, Learning Event 7, Para 3.
12. 1/500 inch, Lesson 3, Learning Event 8, Para 2e.
13. Depth of field, Lesson 3, Learning Event 9, Para 1.
14. Hyperfocal distance, Lesson 3, Learning Event 9, Para 2.
15. The depth of field will extend f-or one/half the hyperfocal distance to infinity, Lesson 3, Learning Event 9, Para 2b.
16. 15 feet, Lesson 3, Learning Event 10, Para a, b, & c.
17. 16 feet, Lesson 3, Learning Event 11, Para 3 & 4.

LESSON 4
APPLY THE BASICS OF COMPOSITION

TASK

Define and state the theory and application of composing the elements of a scene to be photographed.

CONDITIONS

Given information about the definition and principles of composition.

STANDARDS

Demonstrate competency of the task skills and knowledge by responding to the multiple-choice test covering the basics of composition.

REFERENCES

TM 11-401-2

Learning Event 1
DEFINE COMPOSITION

1. Photographic composition is the orderly or pleasing arrangement of the elements within the pictured area. The difference between a snapshot and a strong photograph is how well the photographer applies the elements and principles of composition.
2. Learning the art of good composition is similar in many respects to learning any other skill or profession. A good photographer does not just record whatever he sees; he puts together or composes the picture. To do this the photographer either waits until all objects are properly related, select camera angle, or he places the objects in their proper relationship.
3. Good composition serves a purpose, sets a mood, and tells a story. Your camera will record whatever it sees, exactly as it sees it, without any consideration or feeling of what is happening, or why. It is up to you to capture the location, excitement, and attitude of the event. If you properly place objects in the picture, you will give the photograph more meaning by clearly showing the situation and reflecting the feeling of the occasion.

Learning Event 2

STATE THE PRINCIPLES OF COMPOSITION

1. Composition may not always follow definite rules. There are several guiding principles based on common sense which help a photographer develop an eye for good composition. These basic principles are: Simplicity, Center of Interest, Balance, Direction, Details, Tonal separation, Lighting, Depth, Camera angle, Format, Foreground, Lines, Background, Framing, and Image size.

2. Simplicity. The purpose of a photograph must be clear. It must not be confused with a mass of elements which compete or distract from the main purpose. Simplicity adds dignity and supports the purpose for a detailed and functional photograph.

3. Center of Interest. Every photograph should have one definite center or point of interest which is supported by the remaining elements. The placement of the principle subject or action to gain its center of interest allows the viewer to absorb the meaning of the photograph more clearly and quickly.

a. To locate the ideal site for the center of interest, consider the scene as a tick-tack-toe chart. Place the principle subject on one of the intersections, Figure 4-1.

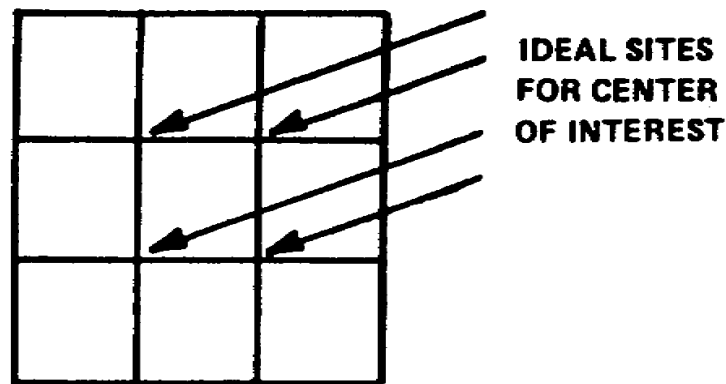


Figure 4-1. Location of center of interest

b. Another point to consider is which of the four intersecting points to place the principle subject. The following rule should help. If the subject is facing left, place it on one of the two points on the right. If facing right, place it on one of the two points on the left. If the subject is looking up, place it on one of the two bottom points. If looking down, place it at one of the top two points. If the subject is facing right and looking up, place him on the bottom left point and so on, Figure 4-2.

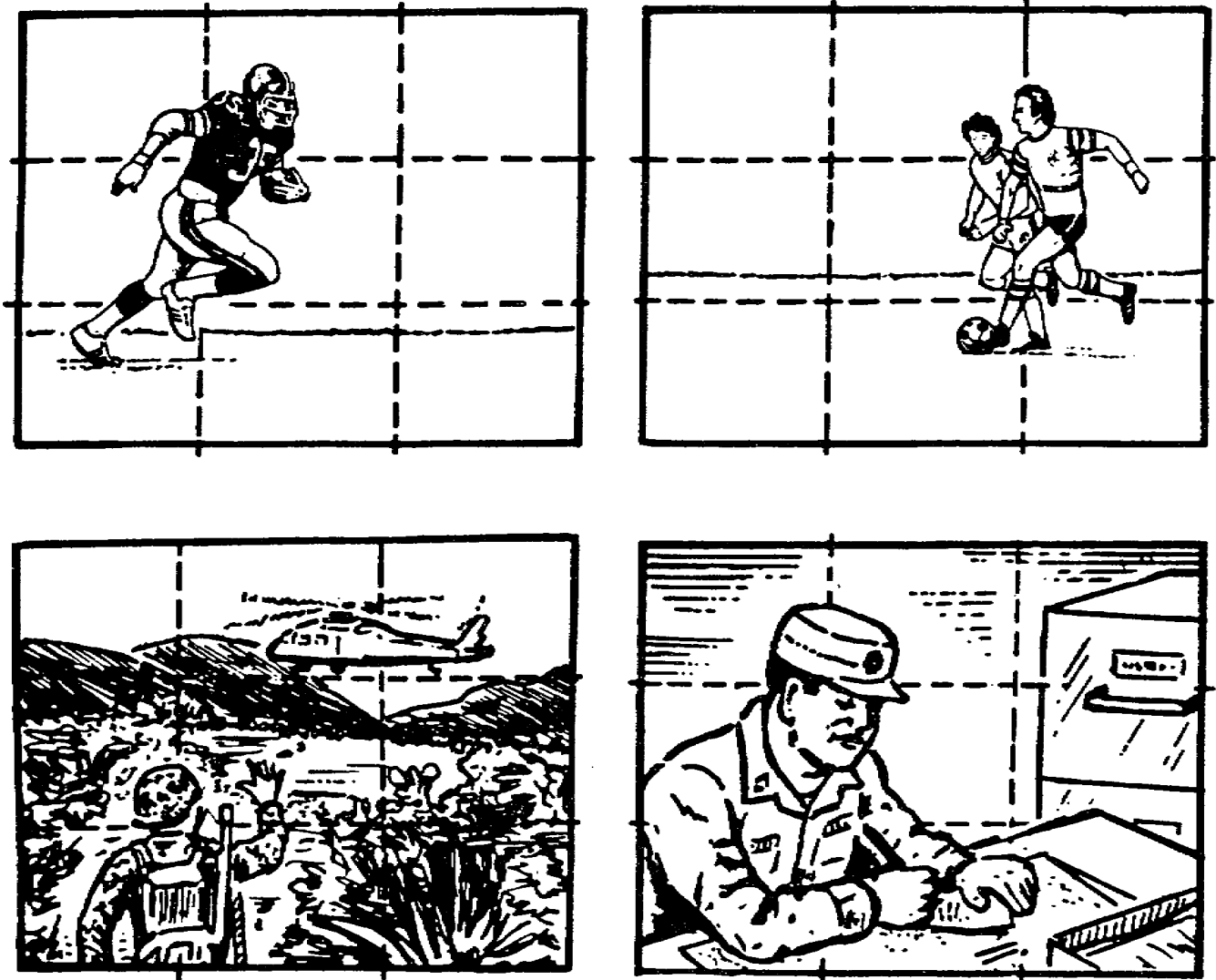


Figure 4-2. Placement of center of interest

c. The rule of thirds states that the ratio of the length of the smaller part of a line to the larger part of that line equals the ratio of the layer part to the whole line. This ratio of $\frac{2}{3}$ is used to locate the placement of the center of interest. It works out that this point of placement is $\frac{2}{3}$ the picture width from either side and $\frac{2}{3}$ the picture height from top or bottom. (Figure 4-3)

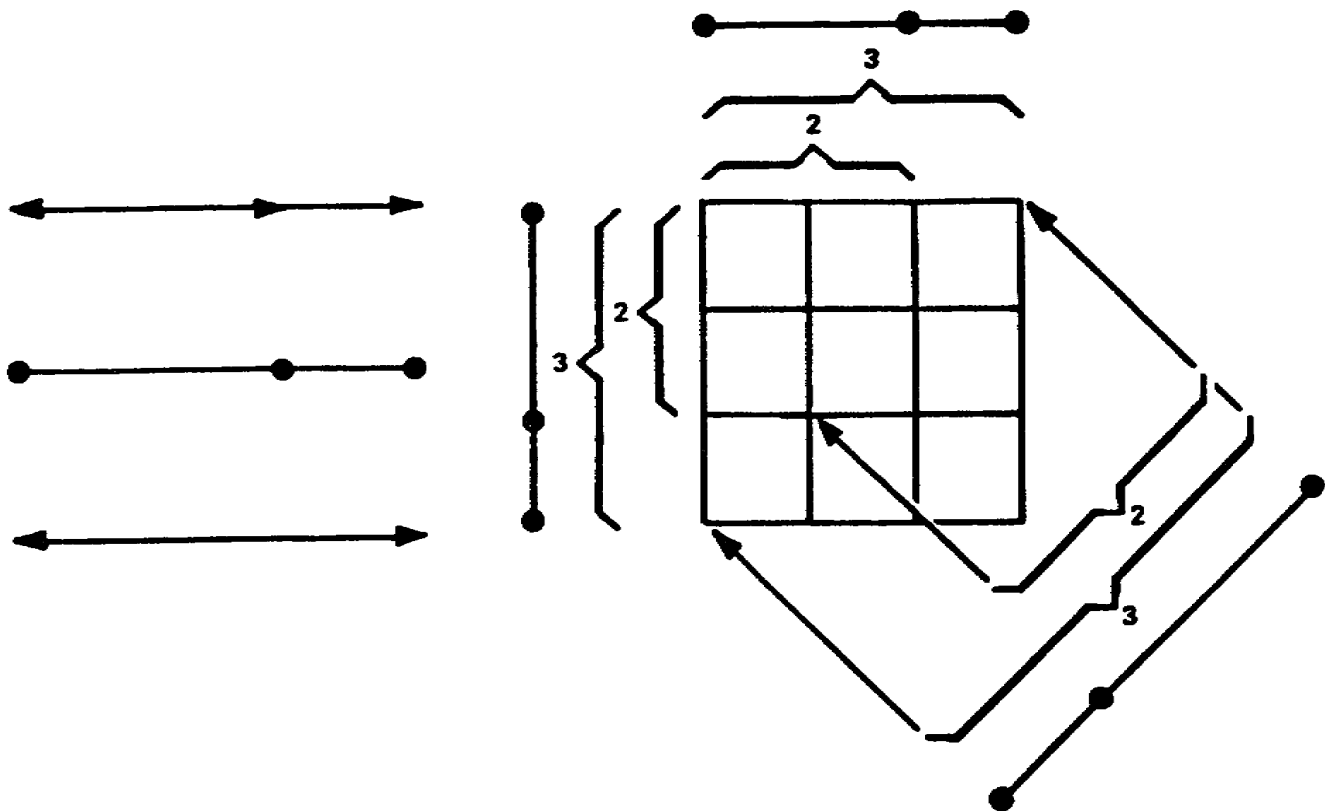


Figure 4-3. Ideal division of a line

d. The center of interest should never be located at the center of a photograph. This creates a hypnotic effect on the viewer. The viewer's eyes go directly to the center almost immediately and will stay there. The viewer will see only that one point. The rest of the photograph is lost. The command of the viewer's attention is also lost if the center of interest is placed near the edge of a photograph. This brings the viewer's gaze to the edge of the photograph and might move his attention away from the subject completely.

4. Balance. Balance in composition means that the various elements in a photograph give harmony to the whole setting. Balance does not mean equality in the placement of the elements. For example, the area in a photograph where a dramatic action occurs has definite weight which must be taken into consideration. There are two primary methods of obtaining balance. One is the balance of objects of the same shape and weight as in Figure 4-4.



Figure 4-4. Balance of like shape and weight

a. A photograph "too balanced" is lifeless and should be avoided. The other option is to balance unlike shapes and weights, which is preferable as in Figures 4-5 and 4-6. When such a photograph is viewed upside down, it will still maintain good balance.

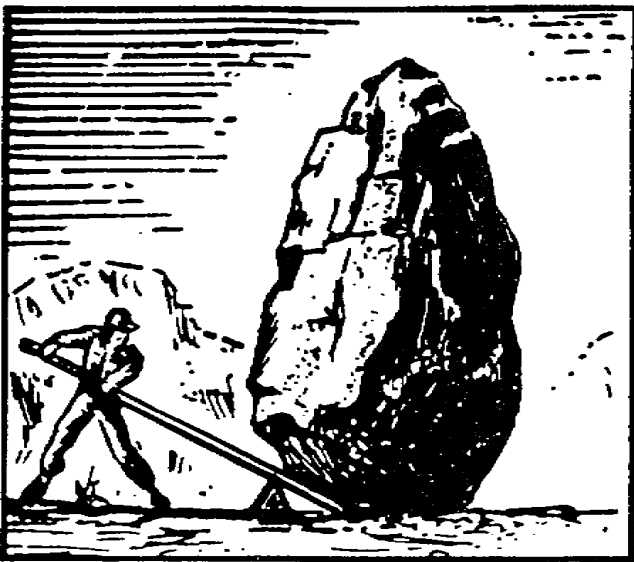


Figure 4-5. Unlike weight



Figure 4-6. Unlike size

b. To simplify balancing equal or unequal masses, divide the photograph area into thirds and place the elements in opposite thirds.

c. Place this fact into your mind where it will not be forgotten. The rules and principles of composition may be bent to achieve the idea or thought you wish to convey. But NEVER EVER balance the composition by dividing the photograph in half. Figure 4-7 and 4-8.

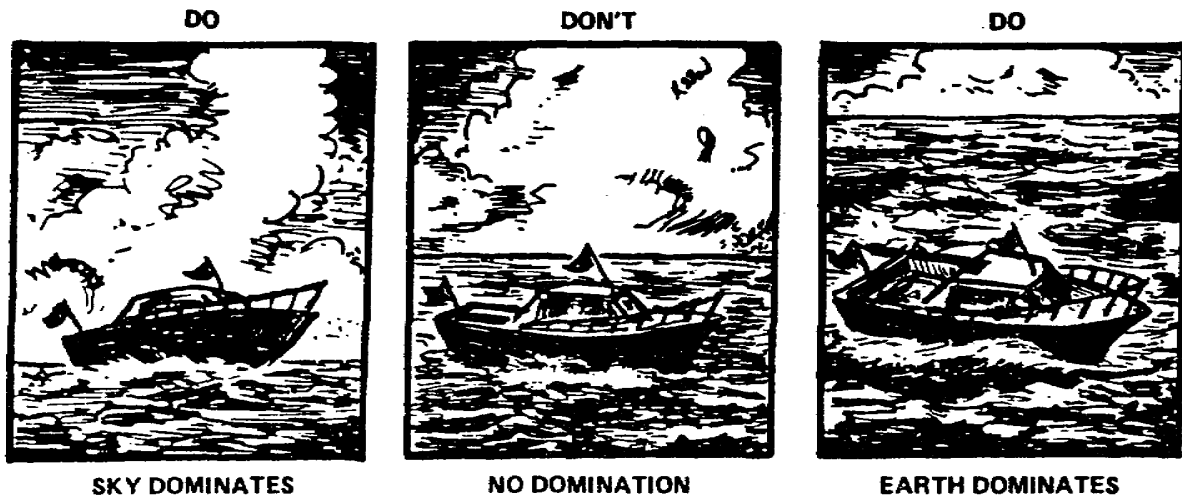


Figure 4-7. Horizontal division



Figure 4-8. Vertical division

5. Lines. Photographers use many different types of lens to add strength to their composition. Lines give structure to photographs and unify composition by directing the viewer's eyes and attention to the main point of interest. Lines can also be used to add to the mood or character of a photograph. There are many types of photographic lines. Leading lines, horizon lines, and characteristic lines are examples of some photograph lines.

a. Leading lines lead the eye or direct attention. An ideal leading line is one that starts near the bottom corner of the scene and continues unbroken until it reaches the point of interest. It should end at this point, otherwise the viewer's attention will be carried beyond the main object in the picture.

A leading line may be any object, or any series of objects, which directs the viewer's eyes toward the point of interest. It may be a road, a fence, a row of trees, a shortline, or even a patch of light or dark tone in the scene. Leading lines give a definite sense of depth.

b. Characteristic lines have meaning and promote certain characteristics.

(1) Horizontal lines indicate peace and quite. This is our position as we lie in restful sleep.

(2) Vertical lines indicate strength and power, for instance, a man standing straight and tall is a picture of control and mastery.

(3) Diagonal lines indicate force and action to illustrate this picture as a man leaning into his work or putting his shoulder to the wheel.

(4) Curved lines indicate grace and charm. For example, the arched body gives beauty to a perfectly executed back dive.

6. Direction. When you look at a picture, its arrangement should lead your eyes to the center of interest. You should use lines to do this; lines that look like lines (fig 4-9), lines that don't look like lines (fig 4-10), outlines (fig 4-11), and even invisible lines (fig 4-12), all can be used as direction lines to lead the viewer to the action at the center of interest.

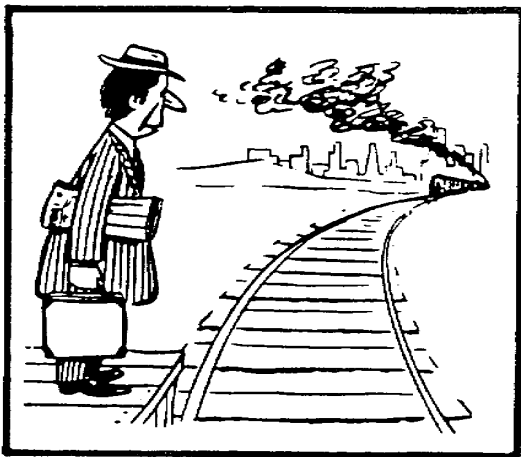


Figure 4-9. Lines that look like lines



Figure 4-10. Lines that don't look like lines

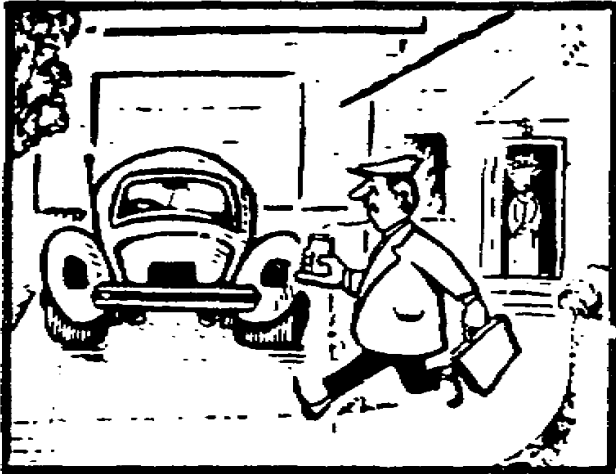


Figure 4-11. Outlines



Figure 4-12. Invisible lines

7. Details. Details support the center of interest but must never dominate or distract from it. Their primary function is to direct attention to the subject matter. Details explain indirectly the purpose of the main theme. Without details, the subject matter will be bare in a void without support, (fig 4-13).



NO DETAIL



DETAIL

Figure 4-13. No detail/detail

8. Tonal Separation. Tonal separation is the difference in shades of gray in a black and white photograph. We see a scene in color, whereas black and white film will only reproduce the scene in shades of gray. Therefore, an object that stands out when seen in color, may now blend into the background. If there is no tonal separation, objects and areas blend together and the result is a loss of detail and clarity. This lack of tonal separation pro-

duces a dull and uninteresting photograph. Correct tonal separation is achieved by using the correct film and filter combinations, covered in SS 0508, good exposure and processing techniques, covered in SS 0509, effective lighting, and most of all, careful subject placement. Think of tonal separation as the opposite of camouflage. Where camouflage hides a subject in the environment. Tonal separation directs the center of interest to the subject by making the subject stand out from the environment. Example, a soldier in white arctic clothing standing in front of a snow covered hill. He blends in with his environment. By placing him in front of green foliage, he will stand out (fig 4-14). Without tonal separation the subject is part of the background/environment.



Figure 4-14. Total separation

9. Lighting. Light is directly connected with composition. Proper lighting produces effective tonal separation and emphasizes the principle point of interest. Light produces highlights and shadows. Shadows can produce leading lines, adding direction. For example, the primary subject setting in a chair reading a book, with a house lamp and shade on her right side (fig 4-15). The highlights would naturally be on her right side and the shadows on the left. If you want to add supplementary lighting to this scene, you should place the "Key Light" in a position to light the subject's right side and use a "Fill Light" to lighten the shadows on the left. If you reversed this lighting set up, the photograph will show the shadow side of her face facing the house lamp. This would create confusion with the viewer.

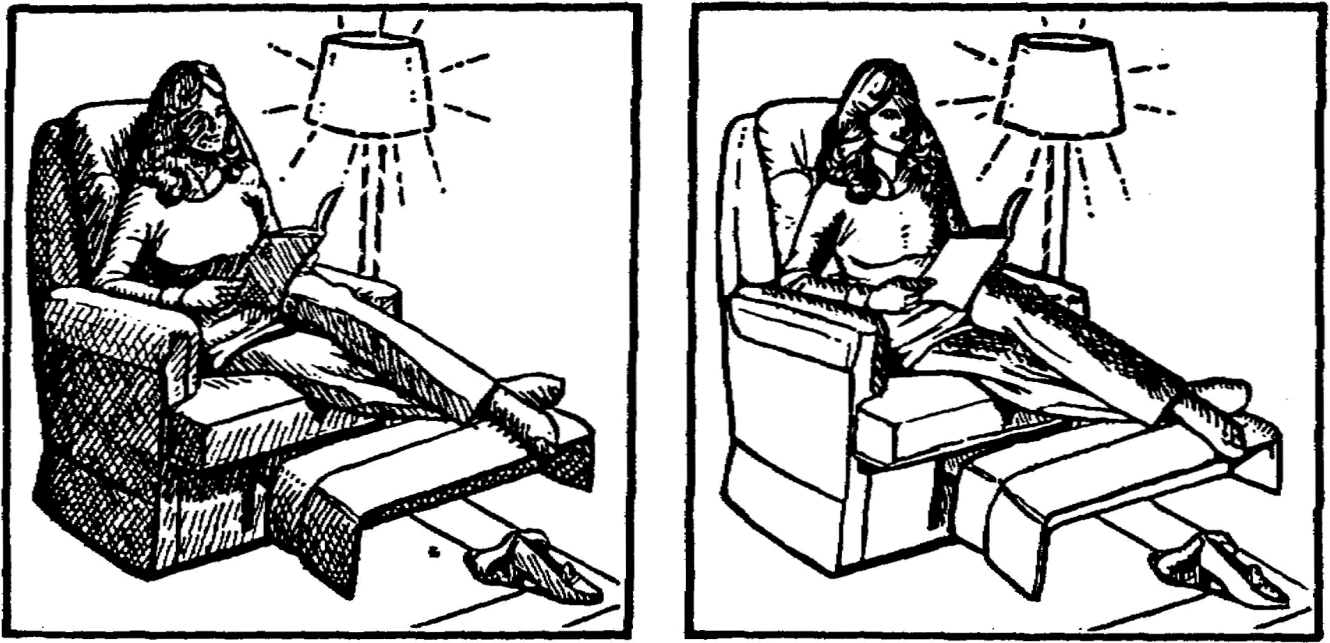


Figure 4-15. Lighting

10. Depth. Photographs are two-dimensional, having height and width but not depth. The photographer must add the missing third dimension by creating an illusion of depth. There are many photographic techniques that create this illusion.

a. A horizon line placed high in the photograph gives a feeling of depth and distance.

b. Haze or mist may also be used to add depth.

c. Light can be used to convey the feeling of depth. Sidelighting produces shadows and shade which give a subject depth and body. Backlighting helps separate the subject from the background.

d. Leading lines or lines that lead into the photograph such as winding roads, fences, rivers, and rows of trees create the illusion of depth.

e. Lens selection plays a large role in creating the illusion of depth. Short focal length exaggerates the distance while long focal lengths compresses the distance.

f. Selective focusing helps separate the subject from the background/foreground thus adding to the feeling of depth.

g. Camera viewpoint or angle.

h. Relative size of objects in foreground and background (fig 4-16).

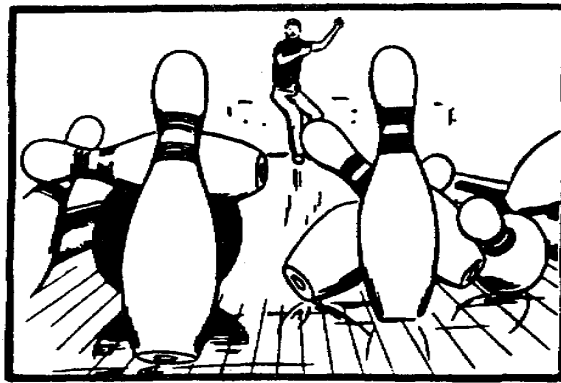


Figure 4-16. Depth

11. Format. Formatting is the process of fitting the subject into a vertical or horizontal space and limiting the photograph area to necessary details. The shape and nature of the subject normally dictates the shape of the format. A low and wide or long subjects require a horizontal format, Figure 4-17. A high and narrow subjects requires a vertical format (fig 4-18).

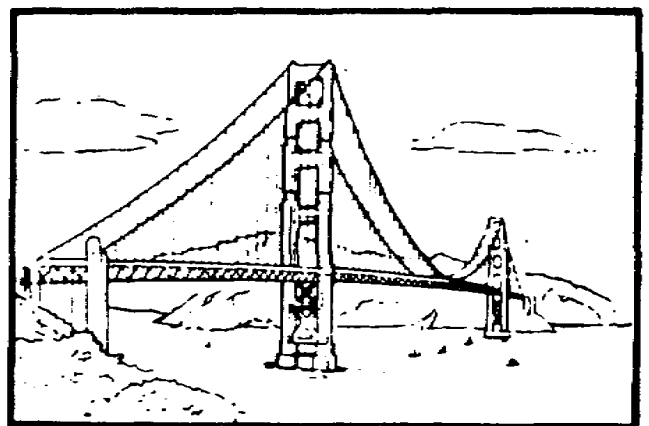
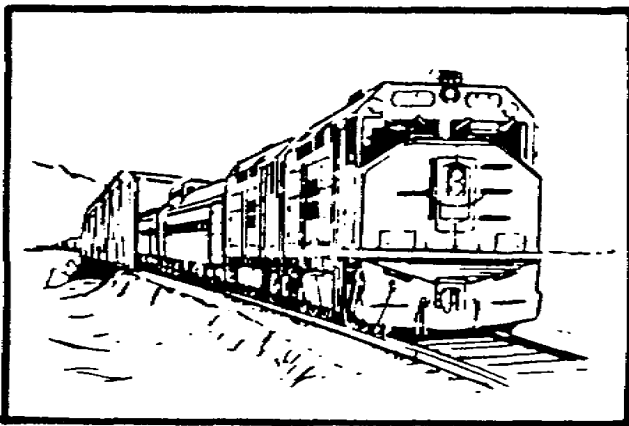
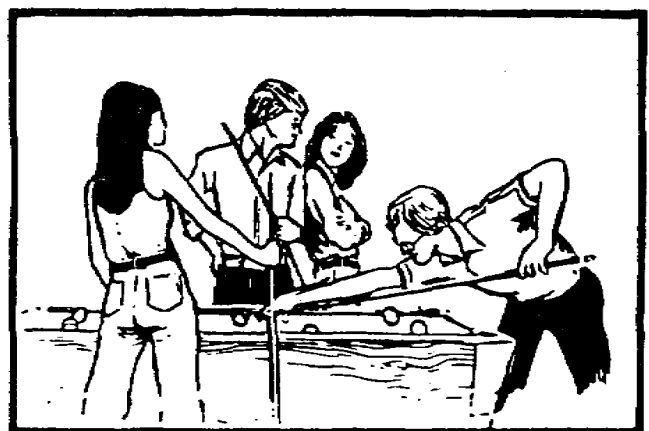
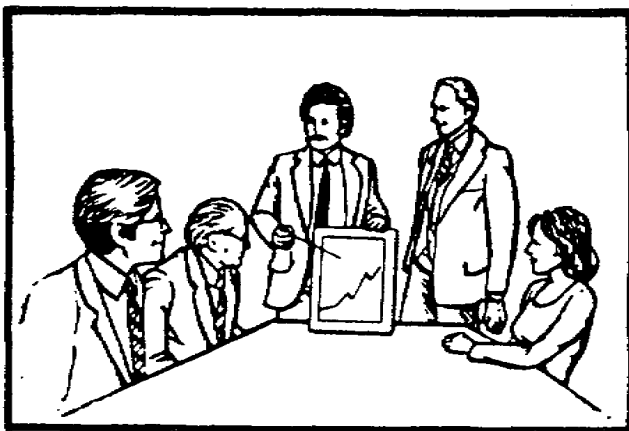


Figure 4-17. Horizontal formats

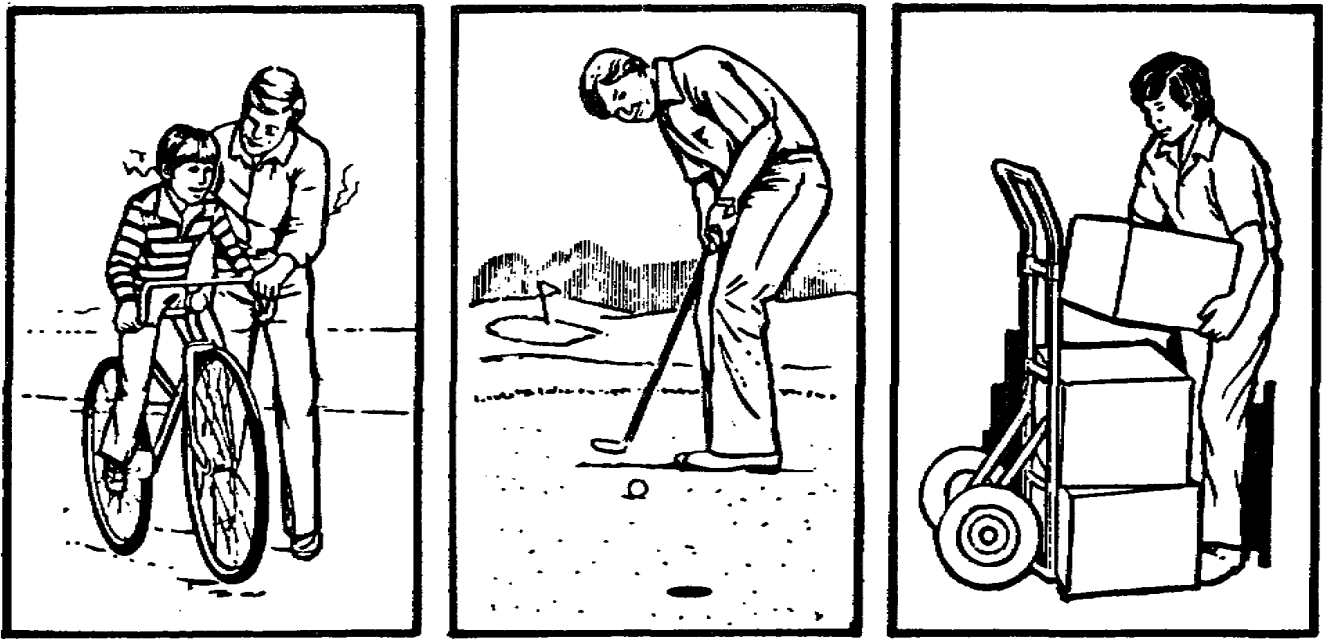


Figure 4-18. Vertical formats

12. Pictorial framing. Pictorial framing is a photographic device used to hold the viewers eye to the center of interest. Almost anything can be used as a framing device, some examples are: tree branches, arches, parts of equipment, anything that helps hold the viewers eye within the frame. A framing device is another means of adding depth and direction (fig 4-19).



Figure 4-19. Pictorial framing

13. Foreground. The foreground furnishes support and adds interest to the subject, by setting the scene. Some examples are:

* A building on a lawn

Adds support (fig 4-20)

* A car on the road

Adds support and direction
(fig 4-21)

* A model standing behind
some flowers

Adds interest (fig 4-22)

* A subject walking on a
walkway towards a house.

Adds support, interest and
direction (fig 4-23)

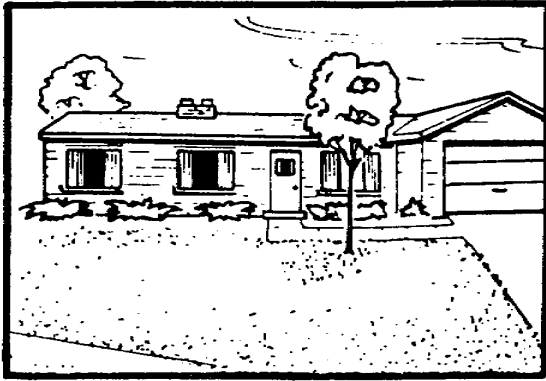


Figure 4-20. Support

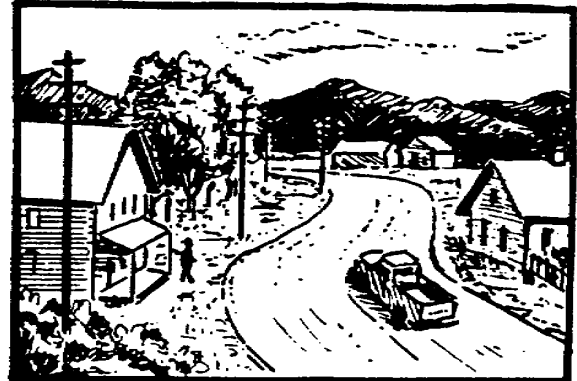


Figure 4-21. Support and direction



Figure 4-22. Interest

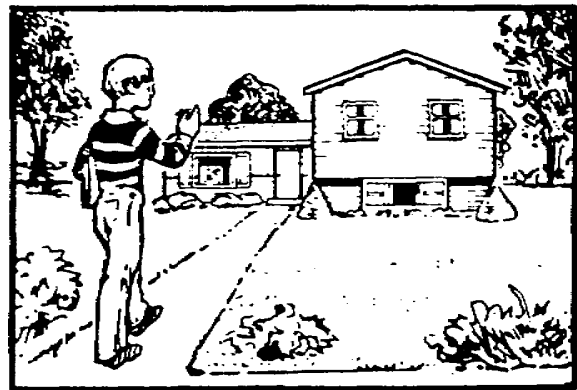


Figure 4-23. Support, interest, and
direction

a. In most cases, the foreground should be in focus and be of sufficient depth to support the subject. Do not let foreground objects detract from the point of interest. As a rule, the foreground will contain the leading line. Consequently, a fuzzy, out of focus foreground will irritate the viewer and detract from the point of interest. Occasionally an out of focus foreground

is used in portraiture where the foreground forms a pictorial frame for the subject.

b. Without foreground, the viewer would be forced to assume the support and sometimes the height of the subject. Whenever a viewer is forced to assume anything, interest is lost.

14. Background. Many photographers overlook the background while composing the photograph. When the finished print is viewed, however, the viewer will quickly realize that the background should have been taken into consideration. This is especially true if the background contains elements that distract from the main subject. Through neglect, the background may destroy the quality of your subject arrangement. Therefore, look beyond the subject and check the background area. In some instances the background will be inappropriate, cluttered, or disorganized. If this is the case, you will have to exercise background control. This can be done in several ways. For instance:

- a. Move the subject to another location.
- b. Change the camera position.
- c. Change the camera angle.
- d. Remove the objectionable background from the composition.

e. Throw the background out of focus by using a large aperture and or longer focal length lens (i.e., limited depth of field). When at a loss for a good background outdoors, get low, tilt the camera up, and use the sky (fig 4-24).

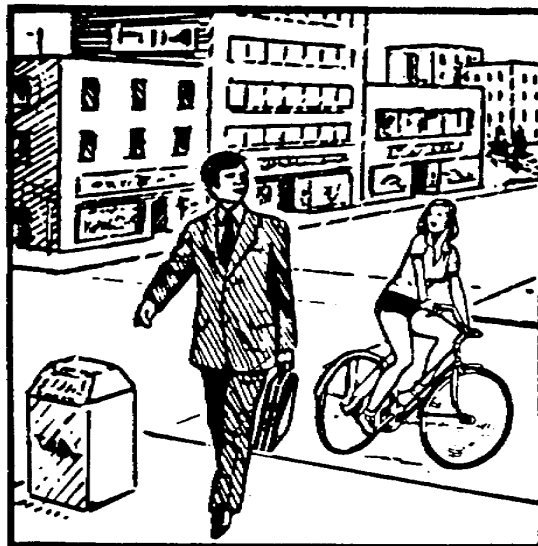


Figure 4-24. Distracting background

15. Image Size. Image size is determined by the lens focal length and the lens to subject distance. In composition, image size adds to the illusion of depth and direction. Image size diminishes from the foreground to the background. Photographers use image size to enhance composition by:

- * A row of trees along a road.

Supports direction and depth.
(fig 4-25)

- * A person in the foreground and a car in the background.

Supports relative sizes. (fig 4-26)

- * A car in the foreground on a winding road with a cabin in the background.

Supports depth and direction
(fig. 4-27)



Figure 4-25. Direction and depth

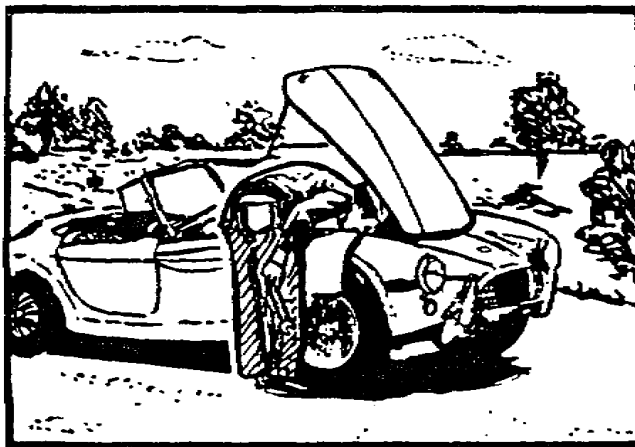


Figure 4-26. Relative sizes

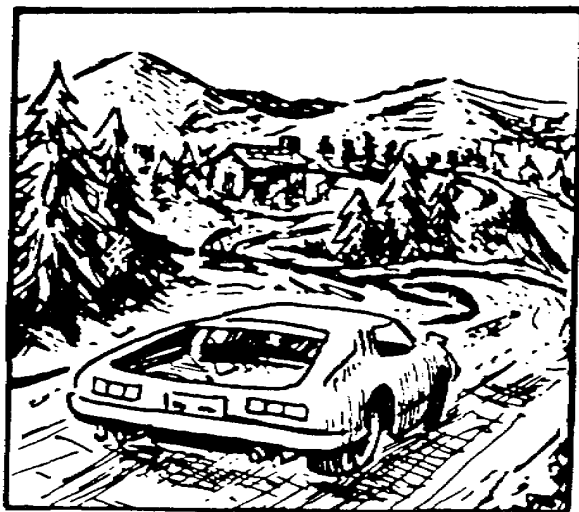


Figure 4-27. Depth and direction

Image size can be controlled also by the height of the camera:

- * To make a tall subject appear small.
- * To make a small subject appear

Use a high camera angle. (fig 4-28)

Use a low camera angle. (fig 4-29)

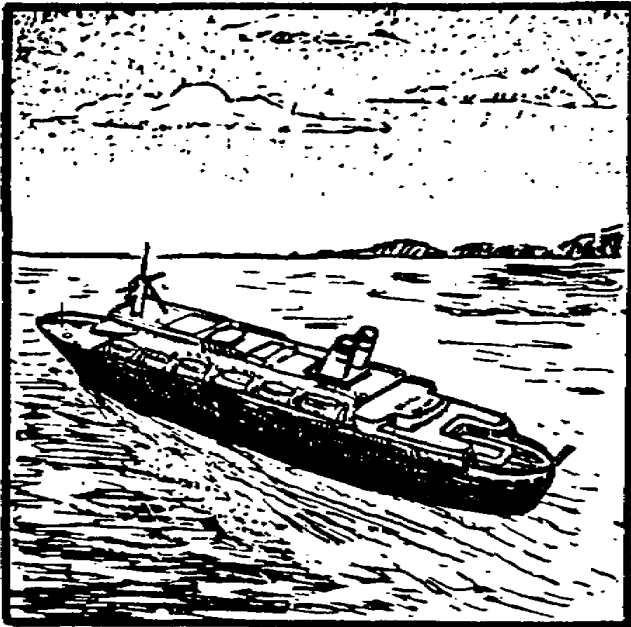


Figure 4-28. High camera angle

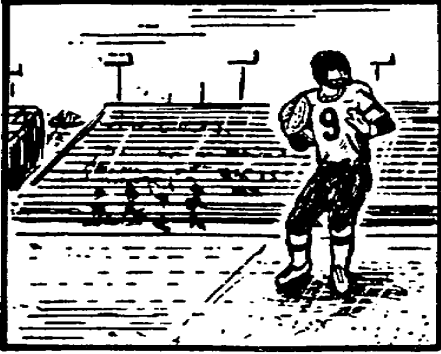


Figure 4-29. Low camera angle

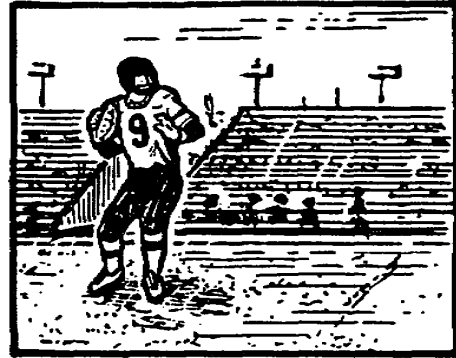
PRACTICE EXERCISE

Select from each which depicts the best composition and state why it was better than the other choice; ile, balance, format, center of interest, depth, direction, detail, framing, lighting, simplicity, tonal separation, foreground, or background.

1.

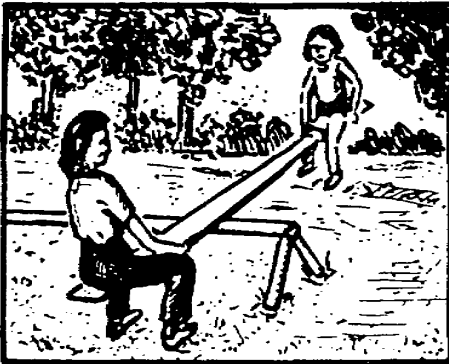


A _____



B _____

2.



A _____

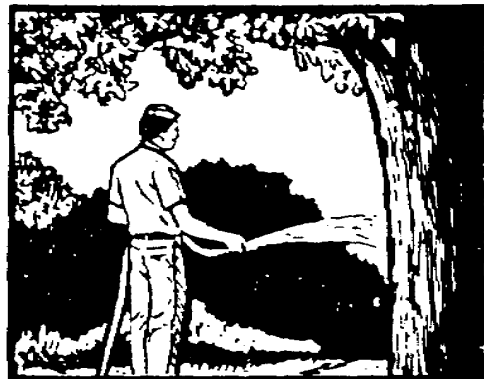


B _____

3.

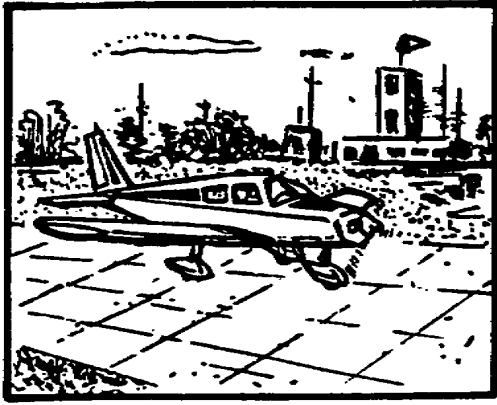


A _____

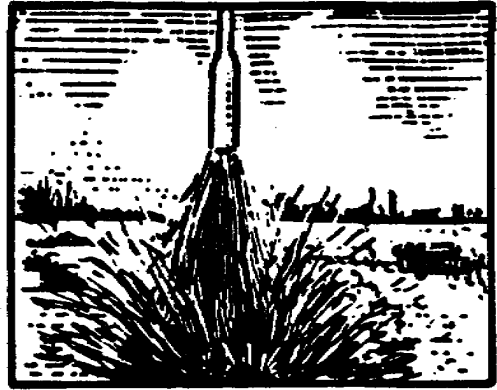


B _____

4.

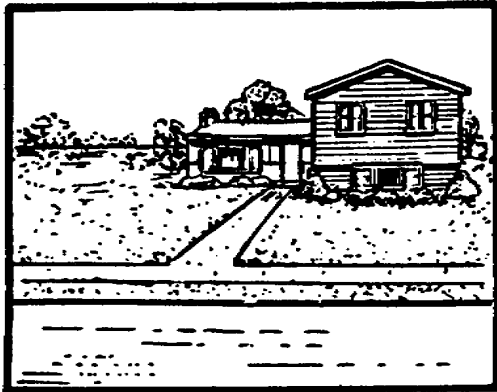


A _____

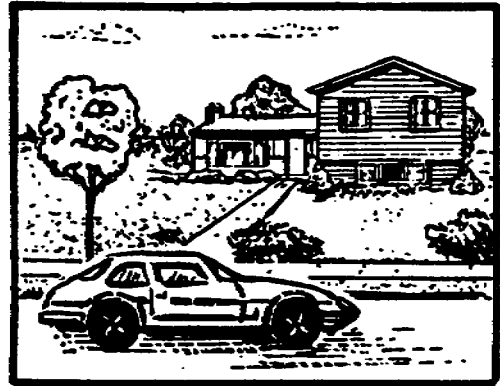


B _____

5.



A _____



B _____

ANSWERS TO PRACTICE EXERCISES

1. b. Center of interest, Lesson 4, Learning Event 2, Para 3.
2. a. Balance, Lesson 4, Learning Event 2, Para 4.
3. b. Pictorial framing, Lesson 4, Learning Event 2, Para 12.
4. a. Format, Lesson 4, Learning Event 2, Para 11.
5. b. Detail, Lesson 4, Learning Event 2, Para 7.